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BECQUEREL, REGNAULT, AND SECCHI.

DURING the last three months science has lost three of its ablest representatives—Becquerel, Regnault, and Secchi. They were among the earliest gleaners in the field of physical research, and contributed much by their example and the fruitfulness of their labors to induce others to devote their energy and talents to the same class of subjects. During forty years and upward they have been in the van of science, and although that period was one of ever increasing activity, they have never ceased to hold the eminent position to which they attained. As their names have been identified, during the last four decades, with scientific progress and discovery, a brief account of their life and labors cannot be without some interest to the general as well as to the scientific reader.

BECQUEREL.

Antoine César Becquerel was born at Chatillon-sur-Loing, in the Loiret, March, 8, 1788. He completed his studies in that nursery of eminent men, the Paris Polytechnic School. The times were troublous and big with wars. Napoleon was at the head of the French army, and the youth of France flocked to his flag. Becquerel left the Polytechnic School in 1808, and entered the corps of engineers. His talents attracted attention and gained for him early promotion. He won his first laurels in the Spanish campaign under General Luchet. In 1812 he returned to Paris, where his military services merited for him the Cross of the Legion of Honor, which he received from the hands of his imperial master. After the disastrous events of 1815 he retired from the army, and turned his attention to the study of science and especially to electricity. The discovery of Volta at the close of the eighteenth century had elicited general attention, and had given rise to a warm controversy. Becquerel, who was inured to strife, eagerly entered the lists as an opponent to Volta. The Italian physicist maintained that the mere contact of dissimilar metals sufficed to produce an electric current, and was the source of power in the "pile," the *couronne de basses*, etc. This was the famous contact theory. Becquerel studied the question in all its bearings, and showed that the development of electricity, even in Volta's original experiment, was entirely due to chemical action. The contact theory was soon abandoned. However, it has a few supporters even at the present day. An effort to revive it was made a few years ago in this country by Professor Fleeming Jenkin, and it is to be regretted that this theory is adopted in the professor's manual of "Electricity and Magnetism," a book otherwise of great value to the science student.

The next subject which engaged the attention of Becquerel was electro-chemistry. Nicholson in 1800 had resolved water into its constituents by the electric current, and Davy, in 1807, succeeded in obtaining, by means of a battery of 250 cells, sodium and potassium from their oxides. The subject was entirely new; facts were needed before laws could be deduced and theories framed. Becquerel supplied the one, Faraday gave out the other. There is, however, but little danger of overstating the value of Becquerel's labors. Whatever the merits of subsequent investigators, he is emphatically the father of electro-chemistry. Among the substances he obtained by electrolytic processes we may mention aluminium, glucinium, silicon, sulphur, crystallized iodine, the double iodides, etc. Besides their theoretical importance, these experiments had considerable commercial value. But Becquerel seems to have been too much preoccupied with their scientific bearing to give to their practical issues the attention necessary to render them commercially successful. Men of a little more utilitarian turn of mind saw in the experiments of 1834, on the reduction of metals from their solutions, a germ which they hastened to cultivate, and which, in 1840, developed into De la Rive's beautiful process of electro-gilding. To Becquerel thus belongs the additional honor of having laid the foundation of electro-metallurgy.

In thermo-electricity he undertook an elaborate series of experiments. He examined a great variety of substances, constructed his copper-sulphide battery, and formulated the well-known thermo-electric series, in which bismuth stands first and antimony last. Nor was atmospheric electricity forgotten. Becquerel made experiments to show that the earth and the air are in different electrical conditions, the air being positive with respect to the latter. He rejected the opinion which attributed the electricity of the atmosphere to evaporation or to the chemical reactions incessantly going on within all organized bodies, and sought to explain the phenomenon on the principle of the unequal distribution of heat throughout the successive strata of the atmosphere. It is well known that when heat is unequally propagated through a wire or any homogeneous metal, those parts which store up the heat and receive an increase of temperature are negatively while the colder portions are positively electrified. Becquerel supposes the same to hold for gaseous bodies. This theory further explains the frequent occurrence of the grand electrical displays observed in polar regions for as the range of temperature is very limited, the electricity developed in lower latitudes would have a tendency to flow toward the poles, where, by its accumulation, it would give rise to the well-known magnificent auroral phenomenon.

From 1867 Becquerel's attention was chiefly directed to electro-capillary action, in which he thought he had found an explanation of the manner in which metals are formed in lodes and veins of rocks.

In addition to his scientific researches and professional duties as lecturer in physics in the Natural History Museum, Becquerel found time to write text-books on all his favorite subjects. These books are all written with a clearness and sequence which show him to be quite familiar with the wants and difficulties of science students. The two most important and extensive of his treatises are on "Electricity and Magnetism" (7 vols. 4to) and on "Terrestrial and Meteorological Physics."

M. Becquerel was admitted to the Academy of Sciences in 1829, and was a corresponding member of our Royal Society. In 1865 he was made Commander of the Legion of Honor and received the decoration from the hands of Napoleon III. A few years ago he was awarded the Copley medal of the Royal Society, being the third French *savant* on whom that distinction has been conferred. He leaves a son, M. Edmond Becquerel, who is already highly distinguished as an original investigator and whose reputation is scarcely second to that of his illustrious father. M. Becquerel was followed, at one day's interval, to his grave by his fellow physicist Regnault.

FATHER SECCHI.

REGNAULT.

Henri Victor Regnault was born at Aix-la-Chapelle, July 21, 1810. Like our own Faraday, his early years were spent in providing for his own subsistence. It occurred to him that in the great metropolis he would be more likely to succeed in getting remunerative employment, which would at once relieve him from the anxieties attendant on a struggle for existence, and afford him an opportunity of indulging his growing fondness for science. At first he entered a large drapery establishment, where his ability won him the esteem of many and the friendship of a few. Happily for him this friendship was more than Platonic, for it soon furnished him with the means of entering the Polytechnic School. He was then in his twentieth year, and we can easily fancy the eagerness with which he listened to and the fidelity with which he noted down the lectures of the most renowned science teachers of the day. Gay-Lussac had just begun a course on chemistry. Noticing the aptitude of his new pupil for manipulation, he made him his assistant, and later on demonstrator. In 1832 he left the school as a mining engineer, and spent the next eight years in the provinces studying, working in the laboratory and lecturing. His favorite study was chemistry; his first researches were on the new science of organic chemistry, and his first passport to distinction was a paper on the preparation of the ethers. In 1840 he returned to Paris, and succeeded to the chair of his illustrious master, Gay-Lussac. Shortly afterward he saw the acme of his ambition realized in his admission to the Academy of Sciences. In the following year (1841) he entered the Collége de France as professor of physics, and in 1847 was appointed chief engineer in the Department of Mines. In 1854 he was made director of the world-famed manufactory at Sèvres, and in 1863 received the Cross of Commander of the Legion of Honor.

Although he acquired his first distinction as a chemist, Regnault soon took up the more congenial study of physics. We cannot say that he showed a brilliant capacity for original work. He was not a Faraday. Perhaps through consciousness of his own endowments he undertook a careful revision of the physical constants which are of paramount importance to every investigator. The task was not an easy one, but Regnault was cut out by nature for an experimenter. Rarely has he been equaled in patience of research, in delicacy of manipulation, or in accuracy of results. He has been rightly called the Prince of Experimenters.

He repeated Dulong and Petit's famous experiment to determine the coefficient of absolute expansion of mercury, and found it to be $\frac{1}{5551}$ between 0 degree and 100 degrees, while the received value was $\frac{1}{5550}$. He found the coefficient of expansion of air to be .003665 instead of .003060, and showed that the coefficient of expansion of any gas increases with its pressure. He devised a new calorimeter, in which he eliminated most of the sources of error inherent to the ordinary application of the method of mixtures, and entered into a minute examination of Dulong and Petit's celebrated law of the constancy of the product of the specific heat and the atomic weight. He found that this product varied in the case of elementary substances between 2·95 and 3·41, while it was practically constant for all compound substances of the same formula and similar constitution. The tension of vapors had been studied by Dalton, and subsequently by Dulong and Arago, but there were some discrepancies in the data obtained. Regnault took up the question anew, and invented a simple and beautiful method based upon the principle that when a liquid enters into ebullition, the tension of its vapors is equal to the pressure it supports. These experiments were carried on with extreme care, and the numbers obtained are believed to be of the greatest accuracy.

Hygrometry also received some attention. In seeking to remove the defects of the usual hygrometrical instruments, he was led to invent the hygrometer which bears his name.

Regnault has written but little. In 1845 he published a small book on hygrometry, and in 1847 an elementary course of chemistry, which has been translated into several languages.

The last years of Regnault's life were embittered by domestic misfortune. In 1871, his only son, who had already acquired a brilliant reputation as a painter, was killed at the battle of Buzenval. "Give me time," said the young soldier-artist to his retreating comrades, "to fix my last cartridge, and I'll be with you." Unfortunately for him, he had scarcely uttered these words when he was struck in the head by a Prussian bullet. By many in this country he will be remembered as the author of one of the most striking paintings of the last International Exhibition, the subject being "An Execution under the Caliphs at Grenada."

During the Franco-Prussian war, M. Regnault was obliged to abandon the manufactory at Sèvres, and when he returned, on the conclusion of the war, he had the bitter disappointment to find that the papers which contained the results of 600 experiments on the heat phenomena accompanying the expansion of gases had been destroyed. He never recovered from this twofold shock; his spirits grew depressed, infirmities increased, and the veteran experimentalist died on January 19, 1878.

SECCHI.

The third great loss which we have to chronicle is that of Father Secchi, the well-known spectroscopist and astronomer.

Angelo Secchi was born at Reggio, July 29, 1818. At an early age his education was intrusted to the Jesuits. He studied mathematics under Dr. Vico, and taught physics in one of the colleges of the Order from 1841 to 1843. In 1848 he proceeded to America and lectured in Georgetown College on mathematics and physics. It was during his connection with this institution that he made the acquaintance of Professor Henry, whom he assisted in his experiments on the temperature of various parts of the solar disk. There is little doubt that the friendship of the Nestor of American *savants* tended to foster the love of original investigation in the young professor, as the experiments he made in the Smithsonian laboratory may have directed his attention to that line of research which he made emphatically his own, and in which he achieved such brilliant results. The spectroscope was a novelty; Bunsen and Kirchoff were founding a new system of analysis, and every day brought marvelous discoveries. Secchi fell to work with characteristic ardor, and applied the new instrument to the study of solar physics. On his return to Europe in 1850 he was appointed director of the Observatory of the Collegio Remand, where every facility and encouragement was given him to continue and complete his labors. Secchi was an indefatigable worker; and, assisted as he was by an able and numerous staff, he collected a great number of observations. These he classified and discussed with rare acumen, bringing to bear upon the discussion all the light of the most recent discoveries. The conclusions he arrived at were embodied in his great work on "The Sun." This book was written in French, which language the learned Jesuit spoke with native grace and fluency. The work forms a quarto of 400 pages, and treats in succession of the structure of the sun, its influence on the universe, and its relation with other heavenly bodies. The author possesses a thorough grasp of his subject, and

expresses his views with clearness and precision. He leaves no point of importance unnoticed, and avoids with equal care superfluity of detail. He finds the surface of the sun to be 60,329 by 10^{14} square meters, its volume to be 139,335 by 10^{22} cubic meters, and its mass to be 19,466 by 10^{26} kilogrammes. He admits the mass of the earth, which is $\frac{1}{324000}$ of that of the sun, to be gradually increasing owing to the fall of shooting stars, bolides, aerolites, etc., and finds in this accession of inter-planetary matter a probable explanation of the secular augmentation of the moon's motion. He maintains the cosmical origin of the sun, and, by the aid of Mayer's hypothesis, endeavors to show that the contraction of the gaseous mass of the sun to its present dimensions would have developed 500 millions thermal units, which he concludes must have been the initial temperature of the solar globe.

The heat of the sun is maintained not by the incessant showering of meteoric matter, as has been warmly advocated, but by the gravitation of the gaseous mass toward its cente.. This contraction would be accompanied by an enormous evolution of heat. The temperature of the sun is however slowly decreasing, and Secchi shows on the principle of the dissociation of gases that this loss does not exceed one degree in 4,000 years. From this he concludes that the time when our globe will cease to be habitable must be very remote. In his valuable work on "Solar Physics," Mr. Norman Lockyer incorporates many of Secchi's results and conclusions. Roscoe, in his standard book on "Spectrum Analysis," adopts his classification of the stars for spectroscopic purposes.

Secchi was not only an irrepressible observer, he was also a very voluminous writer. There are few learned bodies to which he did not contribute valuable papers; but that which has made his reputation, and made it *ære perennius*, is his book on "The Sun."

Secchi erected, at the expense of the Papal treasury, a magnetical observatory with the view of studying the supposed intimate connection between the spots of the sun and the occurrence of magnetic phenomena. These observations were carried on between 1858 and 1870. They showed that years of greater spots are also years of greater magnetic disturbance, and confirmed the coincidence of the sun-spot and magnetic periods (10·45 years).*

During four years, Secchi had at his disposal a telegraph line 31 miles in length, for the sole object of studying the varied phenomena of earth-currents. His published observations show that true earth-currents always exist in telegraph wires, that they have a prevalent direction, and that they acquire great intensity during magnetic storms.

In 1865 there was a general stir among astronomers for obtaining numerous and accurate observations on the total eclipse of July 18th. Celestial photography had been greatly improved by Mr. Warren de la Rue, and there were high and well-founded hopes as to the conclusions which might be drawn from observations made by the new method. Secchi went to Desierto de la Palmas, on the Mediterranean shores of Spain, where he succeeded in taking good photographic records of the various phases of the phenomena, and particularly of the flame-like protuberances. It was there shown that these prominences, which had given rise to so much conflicting speculation, were innumerable, of dazzling brilliancy, rich in photographic rays, of stupendous height, and real solar phenomena. He watched the eclipse of December, 1870 (usually called the Mediterranean eclipse) from Agosta, directing special attention to the corona. It was then proved that different spectra could be obtained from different parts of the corona. These and the numerous spectroscopic observations made by Secchi are ably discussed in his book on the sun.

Besides his intimate and practical acquaintance with physics, Secchi was also a good mathematician. He was appointed by Pius IX. to continue the trigonometrical survey of the Papal States which had been begun by Boscovich in 1751.

At the Paris Exhibition of 1867 he showed his famous meteorograph, and obtained the "great prize" of 100,000 francs. He was a member of most of the learned bodies of Europe, including our own Royal Society, and was the founder of the Italian Spectroscopic Society.

We have already alluded to his ardent application to scientific labors, and we may now add that he retained this energy and eagerness for work down to the last. We are told that even when confined to his bed of sickness, he wished to continue the discharge of his duties as director of the Observatory. He reviewed and discussed with his assistants the daily meteorological observations, and especially those connected with his life-work, the sun. His illness was short but painful. Struck down in the full bloom of manhood, this eminent physicist and astronomer died at Rome on Tuesday, the 26th of February, 1878.

By the demise of these three illustrious men science has sustained a severe loss; but in departing they leave behind them as a legacy to our studious generation their valuable investigations, brilliant discoveries, and, what is perhaps of equal value, a bright example of devotedness and unflagging application to their favorite subjects of research. Their example may induce others to tread in their footsteps, and thus the work which they initiated will be carried on to its full completion.—*Engineering.*

*M. Faye controverts this point. He takes the sun-spot cycle on the authority of Wolf to be 11·1 years; and as the diurnal oscillation period is only 10·45 years, he denies that there is any connection between the two phenomena.

ARCHÆOLOGICAL DISCOVERY IN ROME.

AN important discovery, both from an archæological and an artistic point of view, was lately made in the middle of the Piazza di Pietro, which, it will be remembered, is situated close to the Corso and the Piazza Colonna, and is adorned on one side by the eleven grand Corinthian columns with the cornice intact above them, which are supposed by some to be the remains of the Temple of Neptune, and by others of the Basilica of Antonius Pius.

In digging the course of a new drain the workman, at a depth of about eight feet, came upon a large block of marble, which, on being turned over, proved to be the front of a pedestal, measuring about two meters square, and having upon the face of the dado the figure, in alto-relief, of a Dacian Prince. The figure is a meter and a half in height, the feet resting on the upper moulding of the plinth, the head rising to the cornice. Unfortunately, the face has been destroyed, but the drapery, which is very fine, is perfect in size, form, and every other particular. This pedestal agrees exactly with others found within the area of this Piazza during the Pontificates of Paul III., in 1540, Clement VIII., in 1594, Innocent X., in 1650, while making the conduit for the supply of water to Bernine's grand fountain in the Piazza Navona, and of Alexander VII., in 1660, in demolishing the old Church of San Stefano del Irullo.

CLAMOND'S IMPROVED ELECTRIC THERMO-PILE

THESE improvements relate to the casting and forming of the thermo-electric elements themselves, and to the manner of grouping them together into a pile or generator.

The current obtainable from a thermo-electric element or pair depends, of course, on the two metals employed, the difference of temperature maintained between the ends of the thermo-electric bar, that is to say, between the junction of the metals and the free ends, and the resistance of the bar. With a given pair of metals the strength of current available depends solely on the difference of temperature kept up and the resistance of the bar; the greater the difference of temperature and the less the resistance of the bar, the greater is the current strength obtained. But with the stout bars employed in thermo-piles electric resistance may be neglected. A certain proportion or relation must always exist between the section and the length of a bar, in order that the two extremities may be easily maintained at very great differences of temperature. The result is that when intense currents have been required it has been the custom hitherto in constructing thermo-piles to increase the length and thickness of the thermo-electric bars conjointly; but this plan entails both heavy and costly apparatus, and necessitates the employment of very large masses of metals or alloys. The first improvement in the new patent is designed to remedy this inconvenience by the intervention of a partition or plate of some material, which is a bad conductor of heat and electricity, such as amianthus, terra-cotta, or mica, between the two ends of the thermo-electric bar, without breaking the metallic continuity of the latter, and allowing sufficient sectional area of metal to connect both ends of the bar. By means of this heat screen of non-conducting material, partially dividing the bar into two parts, the heat from the hot end is in great part prevented from radiating and being conducted to the cold end.

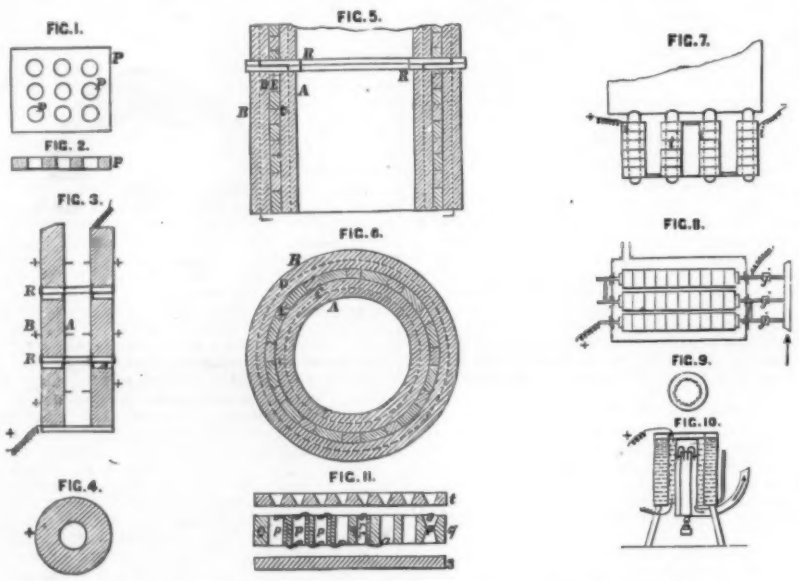
Fig. 1 represents a plan and Fig. 2 a section of this non-conducting diaphragm, such as would be employed for a single square thermo electric bar, *p* and *p* being holes through which the bar is cast, so as to make the alloy continuous. If such a plate be placed in a mould for casting the bar, the metal on each side of it will be united by little cylinders of metal through the holes. Bars thus made are like partitioned metal plates, a form which permits of their sectional area being increased without increasing their length. Great differences of temperature with a very small distance between the pole plate, and consequently a much greater production of electricity with less metal employed and less heat expended, are the results. This diaphragm, as the patent points out, fulfills, in some degree, the function of a porous vase in a voltaic cell, which, while putting two liquids in contact in such a manner as to permit the passage of electricity, prevents them mixing too quickly.

Fig. 11 represents another mode of making elements suitable for the construction of small thermo-piles for domestic purposes. The figure is a section of a group of elements, *q q* being a perforated plate or flat cylinder of plaster of Paris, earthenware, or other non-conductor of heat and electricity. *p p* are perforations into which a thermo-electric alloy (say two parts zinc and one part antimony) is cast; *r r* are wires of German silver, or other thermo-electric metal, one end being cast into the alloy at the bottom of one pole, the other end passing through a hole in the material of the diaphragm to the top of the next pole, where it is likewise cast into the alloy. If preferred, the wire may be coated with asbestos paper, or other insulating material, as shown at *r r*, and cast into the alloy itself. In either case the end of the wire is curved into the form of a ring, so as to give ample conducting surface to the metal to insure good contact. In this way the thermo-electric junctions are formed and connected to each other "in series." The perforations in the diaphragm may with advantage be formed like a double cone, as shown at *b p*, so as to retain the alloy firmly in its place. The plate, *s*, of earthenware or metal, is the bottom of the mould or hearth on which the diaphragm is laid when the casting is made, and *t* is an upper plate pierced with holes, which are arranged opposite the holes in the perforated plate, so that the separate bores may all be filled at once by one ladleful of the melted alloy. The diaphragm, with its accompanying plates, *t* and *s*, may be curved in the form of a segment of a circle, so that two or more segments placed together may form a cylindrical battery. Small piles so formed can be heated over an ordinary gas flame or lamp chimney.

This leads us to the second new improvement, the manner of building up the thermo-electric elements into a pile or battery. The general form selected for the pile is that of a large hollow upright tube, with the heated junctions set round the internal wall, and the cool junctions set round the external wall. Such a tubular pile can be built up of cylindrical elements, connected in series, the positive and negative poles of the pile appearing at the top and bottom of the pile respectively, or *vice versa*. Figs. 3 and 4 exhibit this arrangement of the elements. Each cylindrical element is separated from that above and below it by a non-conducting plate of mica or asbestos, R; all the negative poles are shown at the interior of the tube, and all the positive poles at the exterior, while the two terminal poles of electrodes of the entire battery are shown by wire spirals at the top and bottom. Figs. 5 and 6 represent this mode of arranging the pairs in greater detail, 5 being a vertical and 6 a horizontal section through the pile; A and B are interior and exterior protecting tubes or envelopes covering the pole tubes, C D, which form the junctions with the thermo-electric alloy. To obtain good contact between the alloy and the pole tubes, the latter are made of riddled or pierced metal, or of metallic cloth, so that the molten alloy can permeate them; D is the cool or exterior pole or junction, and C the interior, while E is the non-conducting diaphragm, pierced with holes, and embedded in the thermo-electric alloy. Each single element is, therefore, in the form of a flat cylinder, compounded of the inner and outer pole cylinders, C D, with their protecting cylinders, A B, and the intermediate cylindrical partition of non-conducting material, E, the whole being united by the thermo-electric alloy into one solid ring. Out of these single cylindrical elements the tubular pile is built up after the manner of Fig. 3, where three elements are shown, one above another, forming a tube. If the interior of such a tube of elements be heated while the exterior is kept cool, the inner tube, C, will become a negative pole, while the outer tube, D, will be a positive pole in each of the elements. To connect them up in series for "intensity" currents, it is therefore necessary to join the inner pole cylinder, C, of one ring element to the outer pole cylinder, D, of the next. In this way all the ring elements are connected together and the poles of the battery or generator appear at the ends of the tube as shown. To separate the different elements from each other in the pile, layers or washers, R R, of caoutchouc, asbestos, or other insulating and infusible material, such as is used for steam tubes, are employed.

The necessary source of heat for producing the thermo-electric currents may be obtained from a charcoal fire, from the waste heat of a furnace, or from gas. Where gas is employed as the source of heat, the apparatus is arranged as shown in Fig. 10, which consists of a thermo-electric tube having its interior heated by a flame or brazier. The heating surface is increased by being serrated, and is protected against the immediate contact of the flame by a return flue, which causes the products of combustion to re-traverse the interior before finally passing off by the chimney. The tube is also surrounded on the outside by an envelope of cold water to act as a refrigerator to the outer poles. Two other sources of heat are utilized by the inventor, namely, the steam boiler tubes at a high temperature, and waste steam. Fig. 7 shows the first of these, the tubular piles, *i i*, being made to inclose steam boiler tubes, as in the Field boiler. Fig. 8 shows the second plan, in which tubes receiving steam to be condensed are enveloped by the thermo-electric tubes, which are isolated from them by rings of caoutchouc or other material.

The manufacture of Clamond's new pile in England is in the hands of Latimer Clark, Muirhead & Co., Westminster, London.—*Telegraphic Journal.*



CLAMOND'S IMPROVED ELECTRIC THERMO-PILE.

EXPERIMENTS WITH THE TELEPHONE.

By A. DOMOGET.

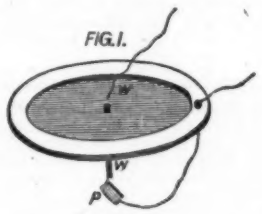
IF two telephones are placed in direct communication with the two wires of a Ruhmkorff's coil so as to close the currents of each of them by means of the wires, and if any one speaks into either of the instruments, the second transmits the sounds as if the two telephones were in direct communication. If any one speaks into a telephone in connection with the thick inducting wire the coil acts as if with a battery, although the currents are alternately inverted, and very feeble discharges are produced at the extremity of the induced wire on bringing them into contact with the tongue by means of two wires of fine copper. The voices of women and children are heard better with vibrating plates of 3 to 5 centimeters in diameter, and the voices of men with plates of 6 to 8 centimeters. If the gamut is sung into a telephone with a large vibrating plate the lowest notes are easily heard, while the higher ones become less distinct. If the vibrating plate is small the case is reversed. At the end of a line two telephones may be placed in a double circuit, and if we speak or sing simultaneously into both the two voices are heard distinctly in a single telephone at the other extremity of the line.

NOTES ON THE TELEPHONE.*

ITS HISTORY AND THE THEORY OF ITS CONSTRUCTION AND OPERATION.

By R. M. FERGUSON, Ph. D., F. R. S. E.

THE articulate telephone is already an old story, though it has not been yet six months on this side of the Atlantic. So perfect is our network of intelligence, so complete our means of popular instruction, that few educated men are without some knowledge of the instrument, and many know all that is known about it. I have, therefore, to introduce no novelty to the Society. So remarkable an invention still possesses, however, enough of interest to engross an evening. Its construction is so simple, and its performance so marvelous, that the interest in it will not soon die down. The telephone marks an era in invention, and the name of its inventor will ever remain familiar in the history of science. Two discoveries of cardinal importance have hailed from America at about the interval of a century, both equally unexpected, equally bold. The first was that of the lightning conductor by Benjamin Franklin, and the other that of the telephone by Professor Graham Bell, both men in the first instance professionally non-scientific—the former being a printer, and the latter a professor of English literature. One would almost fancy, if they had been specially scientific, educated caution would have warned them off from such apparently unlikely and hopeless problems. "To rob the heaven of its lightning," as it has been put, "and to make



the feeble voice of man speak to the uttermost ends of the earth," as it no doubt yet will do, seemed beforehand mere visionary projects. The telephone adds another to the inventions of non-technical men, of which history records so many and so striking instances. While we do not grudge America the credit of the telephone, we recognize with pride that the inventor is a native of this city, and that his respected father was an active member of this Society.

THE NAME OF THE INSTRUMENT.

An interesting discussion took place recently in one of our newspapers as to the difference of the genius of the German and English languages, in so much that the German language named the instrument Fernsprecher or Farspeaker, with native vocables, whereas such was the poverty or pedantry of the English language that we had to borrow from the Greek and call it telephone. It so happens, however, that the man that coined the word and invented the first telephone was Reis, a German schoolmaster, near Frankfort-on-the-Main. I exhibited his instrument before this Society fourteen years ago, and the attention I paid to it then has been of service to me in deciphering what I imagine to be the true theory of the present telephone.

THE REIS TELEPHONE.

I could not lay my hands on a Reis telephone, but I have extemporized one which is the same in principle. Reis used as a sending instrument a stretched diaphragm of skin, at the center of which was a small plate of platinum. On the plate rested the leg—platinum shod—of a metal triangle, and the other two legs effected the poise and the galvanic connection of the arrangements. As the disk was agitated by the voice, the central leg of the triangle kept hopping on the plate, breaking circuit at each vibration. The receiving instrument was a knitting needle in a coil of wire placed in a sounding box. At each break it gave a magnetic tick, and these being emitted in the musical order given, reproduced the musical sounds. The sending instrument I have here is shown in Fig. 1. A copper wire, in passing through the skin, is fixed to it by sealing wax, and ends below in a fine platinum wire, or watch hair-spring turned up at the end, which rubs on a plate of platinum, P. The receiving instrument is also in effect Reis' arrangement, but will be afterward described. It is the two bobbin magnet shown in Fig. 3, with a tin box, B, 3 ins. in diameter, and under ¼ in. deep, lying on its poles. The message can be heard from the poles alone. The box only strengthens it. To show you the advance in telephony, I reproduce the Reis sounds. One note by itself would scarcely be considered musical. It sounds rather like a harsh scratch when sounded by itself, and it only becomes musical by contrast with the sounds which follow. This harshness, which is exactly that produced also by the hopper, is due, among other causes, to this, that neither the hopping leg nor rubbing wire makes only one connection at each break. This is beautifully shown by the Bell telephone. When put in the circuit of a very weak galvanic pair, and held up to the ear, it indicates a couple or a series of ticks, when I put one fine wire of the circuit on another, to close the circuit, although I take the utmost care to make, as I fancy, only one contact. The rubbing of the small hair-like wire on the plate of the present device effects also a make-and-break contact on the inequalities of the plate at each vibration of the diaphragm, accompanied with a sputter of irregular and, so to speak, unintentional contacts and breaks, which, as in the case of the hopper, mar the purity of the sound. There is one peculiarity of this rubbing arrangement. At times the rasping sound ceases, and a clear mellow musical note is produced; and just as you are going to catch the articulate sounds, the rasping returns, or the wire gets out of gear, and its action ceases. Such lucid intervals give us room to hope that not many months will elapse before the galvanic battery is yoked to the telephone. It will then rise from a whisper to a voice, and hold its own in telegraphic lines with other telegraphic instruments. I do not think I am fanciful when I say that I have heard articulate sounds at such times. If such actually were the case, it could only have arisen from sudden changes in the resistance of the circuit introduced by the rubber. If this yoking should ever prove successful, it will be as applicable to the Reis telephone as to Bell's, and the old knitting-pin will be able to tell an articulate tale in accents magnetic, though perhaps not so loud or distinct as its more perfect rival.

* Royal Scottish Society of Arts.

The Reis telephone only created temporary interest. The practical busy world pays little attention to such scientific toys. Some sixteen years roll over, and this rasping telegraph all at once develops into a plain-speaking practical instrument. Had Reis been able to make a proper sending instrument, speaking telegraphy would have been now a thing of the past.

THE BELL TELEPHONE.

To Bell is due the merit—and no small merit is it—of showing that the receiving instrument, if properly made, can also be a sending instrument. I know that such is not the Professor's view of his invention, but I trust, before the evening is over, to show that such is really his merit. His point of departure was quite different from this, and, in his own light, quite original, and, so far as he is concerned, his invention is quite as much his own as he claims it to be. The difference between the two telephones is very much that between a man who can only whistle and one who is in possession of all the refinements of speech and singing; but the whistler has only to know his powers to come into full possession of them. I shall now proceed to describe the Bell instrument, and to give, so far as I understand it, the inventor's theory of it. This last can be best done with the aid of the reflecting galvanometer, an instrument which any one would naturally call in to his aid. I used it as early as October last in elucidating the telephone in the course of my usual work. Fig. 2 is the diagram usually given in explanation. The sending and receiving instruments are *fac-similes* of each other, and are connected by two wires, or by one wire and an earth return, as in ordinary telegraphic circuits. D D are two disks of very fine iron plate, about the size of a crown-piece, placed nearly but not quite in contact with the end of a soft iron pin attached to the pole of the bar-magnets, W, about 6 ins. long and ½ in. in diameter. Bobbins and coils, C, of fine wire, are put on the pins. The disk is nailed to or nipped by the wooden frame of the mouthpiece, or, according to use, the ear-piece of the instrument. When any one speaks in the mouthpiece of the sending instrument, vibrations are produced by the voice in the disk, which accordingly cause the disk to go backward and forward in front of the pin, which is virtually the pole of the magnet. This motion of the disk, by the well-known laws of magneto-electricity, induces electric currents in the coil of wire corresponding in strength with the extent of oscillation. These are sent to the receiving instrument, and, moving in its coil, increase or diminish the strength of its pole. The iron disk in front of it is alternately additionally attracted and let go as the currents are transmitted, and thrown into vibrations, which are precisely similar to those of the sending disk, and tell the same tale to the ear of the listener as the voice of the speaker. I have here a magnet with a coil at its end now connected with the galvanometer. You see as I move this piece of iron in front of its poles backward and forward how beautifully the spot of light reflected by the magnet mirror travels in perfect correspondence. We having only to fancy that, instead of having a moving mirror, we have a moving disk, and the theory of the instrument is complete. There is the most perfect correspondence between the sending and receiving instruments, and no distinction of poles as in a battery. The more perfectly they receive, the more perfectly they send a message. This explanation is beautiful and simple, and one would wish it true; it must always remain the popular one. Unfortunately, however, when narrowly examined, it is found to be a mere hypothesis, and to have as yet no experimental confirmation.

Before proceeding to give reasons for this, I may mention some of the characteristics of the instrument. One's first attempts at telephone-making begin with hearing a voice at the receiving end with confused articulate sounds, conveying no definite word or meaning. Though the instruments are not up to the conversation point, songs can be well heard. The song stage is the lowest in the scale of telephone performance. As success becomes more marked in the construction, the voice is heard to speak, but apparently far off. When something like perfection comes, the voice sounds only a few feet off, and you would be inclined to look over your shoulder to see the speaker. External noise, however, very much modifies this, and what with silence and undivided attention would seem loud becomes vague and confusing. Favorable position tells immensely in one's appreciation of the sound transmitted. In the present state of the instrument silence is needed to insure hearing. I have, however, been able in some instances to hold a conversation amid the noise of a class-room, and some instruments receive a song that is audible to one or two standing with their heads a few feet off. But generally there must be silence, and the instrument must be held close to the ear. To pre-

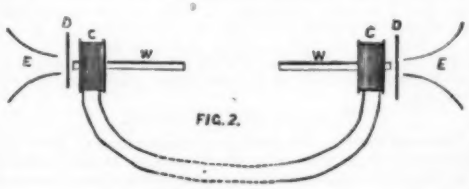


FIG. 2.

vent the confusion that not unfrequently ensues when both speak or hear at the same time, there are two instruments used at each end; and when one gets a long message he puts both up to his ears, and then the message is given with great certainty. Some disappointment is felt that the telephone can only speak to one listener. This is unreasonable, for if one recollects how little of the whole energy of the voice of the speaker is given to the disk—it is, as it were, only one of his listeners—and then the message has to pass through a circuit of wire every yard of which absorbs, though to a very small extent, this energy, it is surprising that even so much of it comes to the listener.

THE WONDERFUL SENSITIVENESS OF THE TELEPHONE.

Scientifically, what strikes one as remarkable about the telephone is its extreme delicacy. A telephone put in a galvanic circuit can indicate very clearly the makes and breaks of contact. I have here a tiny galvanic cell, consisting of two finest iron and copper wires, ·007 in. in diameter, immersed ¼ in. apart for about an inch in distilled water, and when I rub loosely one terminal wire of the circuit against the other, so as to make and break contact, the friction of the wires, inaudible to one standing near, is clearly rendered by the telephone, and that in a circuit of 700 ohms. This signifies that this inappreciable galvanic pair can telegraph audibly through fifty miles of ordinary telegraphic wire. I show you the effect of this pair on the galvanometer; it scarcely moves the spot of light. Such excessive delicacy almost baffles conception, but your astonishment will be moderated when I tell you that the amount of force necessary to make a telephonic disk sound is next to nothing. If you press the disk of a telephone to your ear you can hear, though faintly, the grating of the end of the finest human hair made to rub against it, so exquisite is the sounding power of iron and the sensibility of the ear. No wonder, then, that the induction of neighboring wires in a telegraphic circuit, caused by the faint electric echoes of ceasing currents, is not only sufficient to affect the telephone, but quite to overmaster it. Another remarkable point is the small amount of magnetic power requisite for working the instrument. Professor Bell found that the residual magnetism of a soft iron electro-magnet was quite sufficient. In the form of the instrument which I have made with a horse-shoe magnet, with pole pins at right angles to the plane, I can attach and detach an armature of soft iron. One would fancy that the attachment of the armature would divert the magnetism from the pins, but its removal or attachment does not produce the faintest quiver or variation in the sound sent or received. The fund of magnetic power of an ordinary shilling magnet is thus immensely in excess of the requirements of the instrument.

THE MODUS OPERANDI.

Patent inventions, though protected in the money-making and practical world from imitation, are not exempt from scientific criticism, and it is in this spirit alone that I proceed to indicate some observations I have made as to the *rationale* and form of the telephone. Such of them as are dependent on the ear as a measure of sound I give with some diffidence. The ear, as a judge of loudness, is somewhat capricious. Corporal and external factors enter into its indications. I have sometimes begun with a sound, apparently far off, and by a little training of the ear found it to become wonderfully strong; and again, I have begun with what sounded very loud, and yet, though everything was as

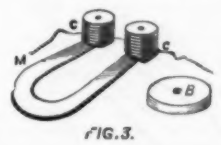


FIG. 3.

before, I could not afterward hear it so well. I have tried to make experiments as nearly at the same time as possible, and if my results are wrong, it is not for want of care. I would make one other remark about them, and that is, that they are by no means complete. Any forms of apparatus I suggest are almost haphazard, and are by no means the best possible. The principle, not the actual form of them, is all I can speak of. I would, in the first place, take exception to the vibration theory of Bell, viz., that it is the vibrations of the disk to and from the pole of the magnet, in excursions proportionate to the intensity, pitch, and quality of the vocal sounds, that electrically affect the instrument; and in so doing I only express the dissatisfaction with it of almost every one who deals with the telephone. The mere vibrations of the iron disk are insufficient to account for its action. I admit that there is vibration both at sending and receiving instruments, and that is indicated by both when the plate falls foul of the pole. The sound is a rattle exactly like a vibratory motion interfered with. I have even observed, or fancied I observed, hat when the fundamental note of the plate was sounded, the succeeding note was blurred by its prolongation. It must, moreover, be admitted that a metal or elastic disk of any kind can reproduce, by its vibrations, all the tones of the human voice. This is abundantly proved by the mechanical telephones that are at present so popular.* These, however, as regards size and thickness, do their work precisely as we should expect vibratory membranes to do, and are no exception to the ordinary laws of acoustics. But in the Bell telephone you have no such simple rule. The size of the disk does not increase its power, and its thickness does not smother the sounds. Beyond a certain size the disk falls off in its work instead of improving, and a message can be received, though with some difficulty, through a disk 1 inch thick. The success of the construction seems to lie in smallness—in confining the action to as thin and as small a disk as is consistent with the action of the mouth and ear. It is an acoustic instrument, *sui generis*, and its smallness seems to point to molecular as well as vibratory action. The following experiment seems to me to imply this :

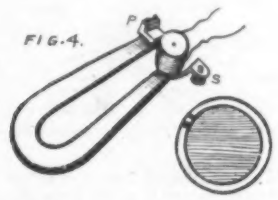
THE DIFFERENCE BETWEEN THE GALVANIC AND THE TELEPHONIC IMPULSE.

First, to show the utmost extent of a disk vibration, I connect a telephone with the galvanometer, and then tap on the disk; the deflection of the spot of light so made must be indefinitely greater than any one made by sound. I put my finger down and keep it there, for if I let it up suddenly again, the motion and counter-motion, producing opposite currents, would eliminate each other. I now lift the finger, and you see that in each case the displacement of the spot of light is hardly ½ in. I now take this two-pole magnet (Fig. 3), and bring quite close to it a heavy piece of iron, one vibration of which sends the light off the scale, and when I cause it to vibrate quickly with my hand, you see the sort of fixed quiver of the light. The currents here generated are indefinitely stronger than those of a telephone can be, and yet if they are dispatched through a telephone their presence is utterly ignored. To make the case still stronger, I take a 28 lb. iron weight, which is a disk of tolerable dimensions, and as I cannot well shake such a disk, in presence of the magnet, I shall shake the magnet in presence of it. Here again the agitation of the spot of light is as before, and the telephone is deaf to the whole proceeding. I shall now vary the experiment. I shall press the magnet close to the weight, and tap very faintly with the handle of a screw driver on the other side of the weight, and the telephone does not miss a single tap. There is something remarkable in the extreme sensitiveness of the telephone to sounds in the disk and core as compared with its indifference to strong undulatory currents. Even when the magnet is placed on an armature of polished iron much heavier than itself and pulled away without noise, the tele-

* On the evening when these notes were read, a Fellow of the Society suggested to me as a test of vibration to attach mechanical telephones to Bell disks. This was done with paper disks 1 inch in diameter stretched on tin tubes, and with sewing threads 1 foot long glued to the Bell disks. When the threads were held taut, a conversation could be managed fairly through this compound mechanical Bell system. This, however, is beside the question discussed here, for these paper disks equally well told the magnetic ticks in the iron of the core of the magnet afterward described.

phone is still silent. The tug felt in drawing away the two from each other might make one think that if any ordinary magneto-electric undulation would affect the telephone, it should be one thus generated. How different is the action of the infinitesimal galvanic pair already referred to. Each individual break makes a distinct tick, though the strength of the current it transmits is immeasurably weaker than that induced by drawing away the armature, and the series of breaks or partial breaks is distinctly heard when the connecting wires run loosely on each other. This surely must arise from the fact that the telephone records an electric break or momentary current but not an undulation. One could scarcely fancy anything nearer a break than the fall of current strength after the first parting of the armature from its magnet. Still the shading away of the current corresponding to the after withdrawal of the iron from the poles prevents anything like a decided break. But it may be said that in vibrating bodies no individual vibration is heard. It is only the vibrations in series in a note or noise that are audible. But how does it happen that the single break in the circuit of almost the weakest pair that can be made is telephoned to perfection, if the principle advanced be not true? It may seem extreme to distinguish thus between a break and an undulation, but I shall cite two other examples. I have a magneto-electric machine that is electrically equivalent to a battery of six or seven Bunsen elements. The armature revolves about forty times in a second, and gives off in the same time eighty currents, each of which is an electric undulation of considerable depth from a high maximum to a low minimum. When I put the telephone in circuit and work the machine, those undulations are rendered by a dull whir mingled with the sound produced in the iron by its rapid rotation. When the motion of the armature is slow, nothing but the latter noise is heard, and the electric undulations do not crop up at all. But if I substitute for this powerful instrument a medical magnetic machine, the wave of which is, even in highly re-

FIG. 4.



sisting circuits, of much less strength, but whose undulations are cut short near their maximum, each electric throb thus imparted sounds like the tap of a hammer, and when the machine is driven fast, the series of such becomes almost insupportable. It is manifest, therefore, that in the telephone an undulation spoiled is an undulation gained, and that if any undulation can have an effect on it, it is not because it is an undulation, but because it approximates to a momentary current. The second illustration is this: I take the finest platinum or German silver wire, and attach one end to the terminal wire of a galvanic pair. I take the other terminal and run it up and down rapidly on the fine wire without breaking contact, so as to lessen or increase the circuit resistance by, in an unbroken way, shutting out or including the resistance of these highly non-conducting wires—the action is not marked by the telephone. If I attach the ends of the fine wire, one to each terminal, and place one terminal on any portion of the fine wire, or take it off, thus shunting off or on the resistance of the intermediate wire at once, the telephone now answers to the electric pulses thus made. It would thus seem that the telephone answers to an electric pulse or break, but is incapable of rendering the fine outline of an undulation, and that each electric pulse is recorded in the instrument as well as the series of them.

A CURIOUS EXPERIMENT.

In continuation of this argument, I would mention an investigation I made with reference to the form of the telephone. It struck me that as in all magnetic actions where the two poles play together, any effect in moving armatures is much enhanced as compared with the action only of one pole, the same would be found in the telephone. All telephones hitherto only bring one pole into play. To test if such would be the case, I constructed a magnet of the shape shown in Fig. 4. I took an ordinary shilling magnet, and screwed an iron pin, ⅞ in. long and ¼ in. in diameter, to one pole, and put a 1 in. bobbin of ·007 copper wire on it. On the other pole an iron stage, P, was erected, to which was screwed an iron ring 3½ ins. outside, 2¾ ins. inside diameter, and ⅛ in. thick. On the under side of the ring a disk was soldered, with as little tin between as possible. The object of the heavy ring was to give body to the disk, and to continue the magnetism of the other pole all round it. I began to construct on the vibrating theory, and found, when I got all to act, that the disk of ferrotype plate conveyed the sound well enough, but was accompanied with a metallic jingle. It was too thin for its size. As I did not wish to make a very loud instrument, but only to try an experiment, I did not change the ring, but used a thicker plate. I found No. 28 or No. 26 untempered steel plate to answer well. For one of the magnets I provided a stage of brass instead of iron, so that I could demonstrate the difference between a two-pole and a one-pole telephone. On sending a message, and keeping one of these in each hand, I found that the iron-staged instrument was louder than the other. To the bobbin sole I fixed a brass arm, S, with an adjusting screw to regulate the distance of the disk from the pin. The effect of distance here is very marked, a thick disk being only raised, and nothing more, from the pin to insure the best effect. Taking off the disk, and laying bare the pin and platform, I now took a box of tinned iron plate, 2 ins. in diameter and 1 in. deep, and putting my ear to the open end, I gradually brought it close to the pin to hear the musical scale sung by a person in a distant room. When the middle of the box was held just over the pin, so as to act clear of it, the sound was as in the usual telephone. I then laid the box down on the pole, and expected the sound to die away. But no; it was still there, but like the faintest echo miles away. I then gradually shifted the box toward the other pole stage, and it grew loud till, when it was fairly on both poles, the sound broke forth again, but not so loud as in the vibrating position. I could, however, not only hear a message, but faintly send one. I then carefully listened to hear any sound that the pin might emit, for I was sure it was there, but I heard none. I next put the magnet in the circuit of a Bunsen cell, charged with water, and produced, so to speak, a galvanic message, by rubbing the connecting wire against its binding screw, and repeated the same experiment with much the same result, only the difference between the vibrating position and the two pole positions was not so marked. The sounds were now loud enough to be heard in a room, and the pin made itself heard at 1 ft. off. I now repeat this experiment. The scratching sounds you thus hear are familiar to any one who has dealt with the Reis telephone, and prove unmistakably the identity in action of the two instruments.

THE THEORY OF THE TELEPHONE.

I proceed to develop what I consider to be the theory of the telephone. The first great contribution to telephony comes from America, where in 1837 Page discovered the sounds that accompany the magnetization of iron. His observations have been very much extended by the Germans. I shall endeavor to demonstrate these sounds to you by means of the two-bobbin magnet I have once or twice referred to; and as it plays a considerable part in my communication, I may here describe it. It is a horse-shoe magnet (Fig. 3), about 5 ins. in length. A pin is screwed at right angles to one pole; and in order to allow the pin on the other pole to be 1½ in. distant, so as to admit of large bobbins on the pins, an iron plate is attached, into which the pin is screwed. The pins are ⅝ in. thick and 1 in. high, the bobbins are nearly 1½ in. in diameter, and are filled with ·007 copper wire. The resistance of the two is 200 ohms. This may not be the best for the purposes for which I use it, but it does well, and I have not sought to change it. The pole pins are flat on the top, and keep fixed any article of iron placed on them, partly by their flatness and partly by the strength of the magnet. When the flat round box (Fig. 3), made of thin sheet, 3 ins. in diameter and ½ in. deep, is put on the pole, the magnetic sounds can be well shown. I work now with Bunsen cells, and I close circuit by dipping this wire in a cup of mercury. A sound is heard, but so faint as to be only heard by those quite near it; but when I break circuit by taking the wire out of the cup, a loud tick is heard audibly for a considerable distance. You hear it almost reaches to the end of the hall. These ticks indicate a new molecular disposition in the iron, its particles in the line of magnetization taking a new set with the magnetism, and then relapsing into their former state on the demagnetization caused by the ceasing current.

MOLECULAR VIBRATIONS OF METALS.

Refined observers, such as Joule, find that the iron lengthens in magnetization, and of course shortens to its old size when left to itself. The sound thus produced is at basis a molecular vibration, though it may involve in it the ordinary transverse and longitudinal vibrations. In the single tick these last sound loudest. In rapid series, however, it is alleged by several observers that it is the molecular vibrations chiefly that sound, though these may be accompanied sympathetically by ordinary vibrations. When you make and break contact suddenly the initial and final tick sound together. If we understood the conditions in which these magnetic sounds are best produced, we should be in a position, I humbly think, to construct the best telephone. We can learn something of these by putting one or two pieces of iron on the poles. To a certain extent size increases the sound, as you will hear, when I put a 2 in., a 4 in., and a 6 in. plate on these poles. Generally, however, a certain size answers best for a certain position of poles. Thin plates are loudest, and thick plates seem to keep the sound within them. I have here an ordinary glue-pot of cast iron, with two holes in it for screwing it tightly to the poles. The ticks from it, though scarcely audible in a room, are given as thin tinkling sounds to those near it. Anything made up in the form of a closed box, however, sounds loudest, as you perceive when I put a 3 in. disk and a 3 in. box on the poles. Shallow boxes can be used instead of plates for telephones. Deep or large boxes, though they may increase a musical sound, sound hollow in speaking. These magnetic sounds are always louder when there is facility of vibration. The magnetic force plays best on the best instrument. Hence, perhaps Bell's vibrating disk is the best form of development or resonance for these magnetic sounds. He has discovered a method of making magnetic sounds loud and audible, just as a musical instrument maker succeeds best who makes the best sounding box for his strings. The tick, too, that a plate gives out is almost exactly what it emits when it is gently tapped, and when you tick and tap alternately with about the same loudness you can scarcely discern the difference. We have, however, at basis a molecular action, of which the vibrations of the armature plate are but a manifestation. We may have in its vibrations a momentary redistribution of magnetic matter in a magnetic field; but it is not the simple play between magnet and keeper that is the essence of Professor Bell's theory. The action occurs when the keeper lies fixed on the poles, and without a keeper at all, for with electric messages powerful enough the core of the magnet itself sounds without any aid. The magnetic conditions of this action are as yet comparatively unexplored territory.

MAGNETIC MUSICAL SOUNDS.

The next stage in the history of telephony was Reis' application of these ticks to the telegraphing of musical sounds. The magnetic ticks of the plates and vessels just examined are, for the most part, the fundamental notes produced by transverse vibrations. When the current is frequently interrupted, the individual ticks are no longer observed, and a note is produced, dependent in pitch solely on the frequency of the interruptions. This note is, however, accompanied by the metallic clang of the fundamental note, and the sharpness of the former is thereby much impaired. It is therefore of the utmost importance to suppress this confusing accompaniment, and this is done in every good telephone by damping or muffling the fundamental note. This is effected by jamming the diaphragm between two pieces of wood, so that it sounds dull and dead, quite without clang. When a weak galvanic pair is extemporized by putting the blade of a knife in a tumbler of ordinary water, and the other element is supplied by the end of the copper wire coming from the binding screw of a Bell telephone, and when the wire from the other screw is made to touch the part of the knife above the water, the first magnetic tick is heard, and when it is lifted, the second sounds. In either case it is a dull tap. The loudness and unmusical character of these ticks is a rough test of the loudness and definition of the instrument. It conforms to acoustic principles that any single vibration repeated with any degree of intensity, in any order, and with any rapidity, will be able to render all the complexities of articulate speech. The magnetic tick or tremor is capable of all this. We have but to send electric currents, which are the electric interpretation of these sounds, to such a magnetic arrangement, and the tick will reproduce them to perfection. Everything depends on the perfection of the sending instrument, and therein chiefly lay the imperfection of the Reis telephone.

THE CROWNING POINT.

We now come to the crowning stage in the history of telephony. Professor Graham Bell, in addition to developing the receiving instrument of Reis, has shown that the receiving instrument makes a perfect sending instrument. That it does so as he represents is open, as we have shown, to grave question. It is much more likely that the sending action is the converse of the receiving action, viz., instead of electricity producing sound through molecular action, that sound produces electricity through molecular action. Vibrations play their part in this as in the magnetic tick, in some way heightening the action. Each element of sound may be something like the tick which is converted into a momentary current, and recorded at the other end. If there be such molecularly generated currents, their presence has not hitherto been suspected. Nothing but a magnetic substance produces them, nothing but such can reveal their existence.

MOLECULAR VIBRATION THE CAUSE OF THE SOUNDS.

I would sum up what I humbly submit as the theory of this perplexing instrument. At the receiving station it can be proved well nigh to demonstration that it is a molecular tremor or vibration, and not a vibration mechanically produced, that emits the sound, and this molecular vibration becomes louder the easier the sounding body vibrates. Seeing that there is the most perfect correspondence between the sending and receiving instruments, there is every reason to believe that the sending instrument exhibits the converse action to the receiving instrument, and that there again sound acts on iron, so as to produce molecular changes, the electric power of which is much enhanced by the vibration of the sounding body.

A NEW FORM OF THE TELEPHONE.

To show that this theory is not all speculation, I introduce to your notice a new form of the telephone, half Reis, half Bell. It is nothing else than the two-bobbin magnet—Fig. 3—with the shallow tin box, B, placed on its poles. Here there is no vibrating disk. We might call it a fixed plate telephone, for the box is held firmly by the poles. With two such instruments I have occasionally worked quite satisfactorily; but as it is only here in pieces, and not put up for use, its action is not yet quite to be depended on. However, it has reached the stage that, with a disk telephone at the one end and it at the other, messages can be clearly given and received by it. I have had no labor in the construction, as the parts of it were made to develop magnetic sounds. It might be called a free-and-easy telephone, for any scrap of iron laid on the poles will send or receive a message in a sort of way, very much proportional to the powers, as you have heard, of showing magnetic ticks. I can easily send a musical message through this cast-iron glue pot—sometimes even a verbal message. I can also with ease deliver a message through a biscuit tin. The shallow tin box is selected because it is the most resonant of magnetic sounds. Still, even here vibration follows hard on the heels of molecular action, for I cannot screw these boxes firmly to the poles without very much weakening the sound. They can be pressed, however, by a wooden frame on the poles without compromising their action. On the other hand, if they rock on their poles, the message is not well sent. The bearing of the fixed plate telephone on the drift of these notes must be evident to any one. Reis' telephone was an iron wire in a coil. In the present apparatus the wire and coil is only bent up into a horseshoe form, and a box put on the top. The wire or core of the magnet emits sound, when the currents transmitted are strong enough. The box only serves to bring them into relief. With weak currents I must use the box, for my ear is not sensitive enough to hear them in the core. So much for galvanic currents. With telephonic currents the box is again necessary. Is it not almost a certainty that I should also hear by the core if my ear were sharper? The Bell receiver is thus not essentially different from the Reis receiver; it is only an improved modification. When I speak through one of these telephones, I use an instrument, in my opinion, identical with Bell's; and when I receive at the other end, I have only the developed knitting pin and coil of Reis.

Before concluding, I would only guard myself against the possible imputation of not fully appreciating the genius of the man who has presented the world with this wonderful gift. I have endeavored to prove that in future books of science Bell's discoveries will be given as twofold; first, having devised, perhaps, the best way of developing magnetic sounds in iron; and, second, of showing that the condition produced in iron by external sounds results in electricity. But I cannot close my eyes to the fact that it is easy to register or examine a thing when it is got. The getting of it is the important matter. Every problem is easy when it is solved, but that does not detract from the merit of him who solved it. Professor Bell has furnished new material for thought and advancement, which others may work up as they may, but his is the merit of creative power.

A VISIT TO THE INVENTOR OF THE PHONOGRAPH.

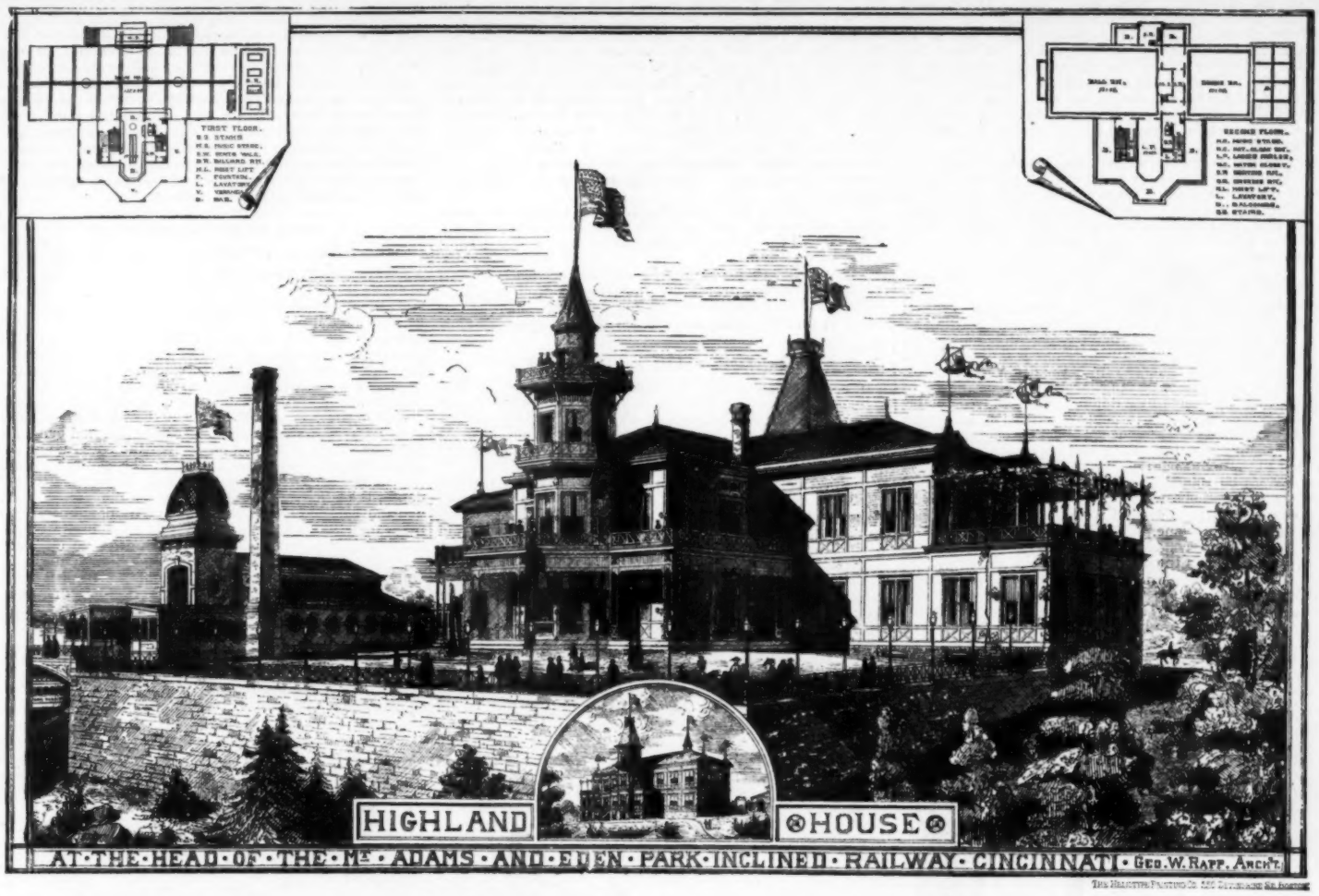
A REPORTER of the *World* recently called upon Professor Edison at his laboratory in Menlo Park, N. J. After greetings had been exchanged the reporter asked, "How is the phonograph to-day, Mr. Edison?" "Oh, about the same as usual," was the answer; "but come and ask it. It has an answer for every man, and generally in his own words."

The reporter followed Mr. Edison to an upper room, where the phonograph was resting on a table, and as the cylinder slowly turned he shouted at it, pleasantly: "How are you?" Then the cylinder was shifted backward and again turned, and the phonograph cried out in the same cheerful tone that the reporter had used: "How are you?"

Mr. Edison seated himself before his favorite invention, and talked, scolded, sung and whistled to it for a while, receiving answers according to his folly or his wisdom. After a few moments the Professor threw himself back in his chair and gazed abstractedly before him. Then he said, "It is funny, after all. You have to pucker up your mouth to whistle, but the phonograph doesn't pucker one bit. Martin," he continued, calling to one of his workmen, "come here and sing bass for me."

A double mouthpiece was placed over the diaphragm of the instrument, and while Professor Edison sang "John Brown's Body" in a loud voice at one side, Martin struggled at the other side with a bass so deep that the air vibrations were about only three a minute.

"You didn't sing loud enough," said the Professor, as he shifted the cylinder



"Well, no," answered Martin; "I couldn't jest git the right chord. But we got it 'hunky' the other day."

The crank was then turned, and the air of the song was sung by the phonograph, with an occasional far-off bass note struggling to be heard. Mr. Edison thought he could improve upon this rendering, and he again sang the song as a solo to the same sheet of foil. When the cylinder was revolved this time the air burst forth with vigor, once or twice failing to connect where a note had dragged in the second singing of the tune.

Mr. Edison now rested himself, and the reporter cast his eyes about the room, at the ceiling and on the floor. Overhead was a net of telegraph wires resembling a huge spider's web, all terminating in a large battery placed in the center of the room.

"Do you use all those wires?" asked the reporter.

"Oh, yes," was the answer.

"Why do you have that pipe-organ that stands in the corner?"

"To record sound."

"What is that thing over there?"

"A part of my aerophone."

"What is that other thing that man is working on?"

"An instrument for reproducing handwriting. I think it will be finished soon."

"What is this circular plate?"

"Oh, that's for taking messages."

The reporter now took a turn around the room. There were thousands of small and large bottles, containing chemicals, drugs and oils, ranged on shelves against three of the walls. There were hydrofluosilicic acid, chloroform, ether, chloral-hydrate, ammoniated tincture of gum guaiac, iodide of potassium, kerosene oil, sulphuric acid and other things of widely different uses.

"What is the idea of your keeping a wholesale drug-store here, Mr. Edison?" asked the reporter.

"Well, answered the Professor, "I keep all those things because I don't know how soon I may need them. Whenever I see a new chemical or drug announced I buy it, no matter what it costs. Now, here's something I prepared," and he handed the reporter a bottle containing a clear, straw-colored liquid. "That's composed of morphine, chloral-hydrate, chloroform, nitrite of amyle, cassia and cloves. Those things have no chemical action on each other, and they'll stop any kind of pain immediately."

During all this time the telegraphic receiver at the other end of the room had been clicking with messages that were passing over the wire. Suddenly there was a slight change in the click, and Mr. Edison, although somewhat deaf, instantly detecting the variation, ran to the instrument and took by ear a message intended for him.

When he had read it he said: "By the way, Professor Bartlett, of the University of Pennsylvania, is going to deliver a lecture soon, and half of it is to be talked to the phonograph. Then I'll attach the instrument to the telephone and send the lecture to Philadelphia. I have just received a letter," he continued, "saying that the phonograph has been exhibited before the French Academy, and that every one was delighted with it. Mr. Hervey, the electrician, has sent me his congratulations."

"Aren't you a good deal of a wizard, Mr. Edison?" asked the reporter.

"Oh, no," he answered, with one of his pleasant laughs; "I don't believe much in that sort of thing. I went to see Heller the other night. His tricks are very good and very smart, but I figured out all of them excepting one. The 'second-sight' is the thinnest of all. But come down stairs, and I'll show you the new model of the phonograph."

The reporter followed Mr. Edison into the work room, where about a dozen lathes and machines were in full operation. On one of the tables was the model. The improvement in the phonograph consists in a circular plate being substituted for the cylinder, and clock-work for the crank.

"This clock-movement is a very important improvement," said Mr. Edison. "It insures complete regularity and accuracy, and can be thrown out of and into gear instantaneously. We're going to start a publication office in New York when the phonograph is ready."

"What do you intend to publish?" asked the reporter.

"Music, novels, general literature and many other kinds of matter that are read by persons and reproduced by instruments or their vocal organs for the benefit of themselves and other persons. Take music to begin with. We will phonograph orchestral concerts by brass and string bands, instrumental and vocal solos and part songs. The sheets bearing the sound impressions of this music will be removed from the phonograph and multiplied to any extent by electrotyping, and persons can make selections of any compositions they desire. Then this music may be reproduced by any phonograph, with all the original sweetness and expression; and not only that, but the pitch can be raised or lowered by increasing or diminishing the speed of the phonograph."

"What will such a sheet of music cost?"

"About 25 cents."

"But how can you take an orchestra, when it is necessary, in talking to the phonograph, to apply your mouth close to the diaphragm?"

"The phonograph will be attached to a hole in one end of a barrel, and from the other end will project a funnel like those used in ventilating steamships. This will receive the music from the entire orchestra, but of course not reproduce it with so great a volume. Piano music will be phonographed by a hood being placed over the instrument, and the volume of the reproduction will be one-fourth that of the piano."

"What method will be pursued with literary matter?" asked the reporter.

"We calculate that an ordinary 50-cent novel can be got on this," said Mr. Edison, tapping the circular plate, which was about six inches in diameter. "Novels and valuable literature will be read to the phonograph by elocutionists and persons understanding the subjects presented, and the matter will be multiplied by electrotyping in the same manner as music. You see, therefore, that you can have a phonograph in your parlor with an album of selected phonographic matter lying beside it. You can take a sheet from the album, place it on the phonograph, start the clock-work and have a symphony performed. Then by changing the sheet you can listen to a chapter or two from a favorite novel, and this may be followed by a song, a duet or a quartet. At the close the young people may indulge in a waltz, in which all may join, for no one need be asked to play the dance-music. You can easily see," continued the Professor, "what an advantage the phonograph will be to the blind; and, indeed, I have already received one hundred orders from such persons."

"In some respects the phonograph will be a blessing to persons who are constitutionally tired," suggested the reporter.

"Yes, and to industrious persons, also," answered Mr. Edison. "You know a man can never judge of the value of his own words or exactly how to deliver them by hearing his own voice. Now, if a lawyer speaks an address to the phonograph in the way he thinks it should be rendered, and then has the instrument repeat it, he can estimate very fairly what the effect would be on a Court and jury. Again, there are many men who can talk better than they can write. They can, therefore, talk to the phonograph without the hindrance necessarily caused by using a pen; they can stop when they please and wait for ideas, and then they can let some one else copy the production as the phonograph repeats it. You see this opens up a vast field, and one suggestion follows another. Now," continued Mr. Edison, with another of his happy laughs, "the lover, while waiting for his sweetheart to finish her toilet, can place on the phonograph a sheet of the pretty things she has said to him before, and so occupy himself for a time with her counterfeit presentment."

"What will be the cost of a phonograph?"

"About $100. The instrument will be finished in all styles and handsomely decorated."

"But how about the aerophone?" asked the reporter.

"Oh, I haven't time to attend to that," replied Mr. Edison, "I'm so busy with the phonograph. The aerophone is very simple. It isn't like a calliope, which requires a keyboard and different notes. It has only one note, and the vibrations of that are formed into words by the escape of the steam."

"What are all these things?" asked the reporter, for the first time discovering a show case filled with a litter of strange objects.

"Those are odds and ends," was the answer. "I haven't got to them yet."

The reporter by this time had become convinced that if Mr. Edison had leisure he would find out the use of everything, however common:

A primrose by the river's brim
A yellow primrose was to him,
And——

it was something more. The reporter was about founding a question on this thought when he discovered that Mr. Edison had disappeared.

"He has become offended," thought the reporter, "at being questioned so much, and has gone away." But this was a mistake. In a few moments Mr. Edison returned, followed by a man bearing a large tray. This was placed on a table, and the napkin being removed, a bountiful lunch was discovered.

"Pitch in," said Mr. Edison.

The scientific inquiries here ended.

CINCINNATI INCLINED PLANES.—THE HIGHLAND HOUSE.

ONE of the most interesting features of Cincinnati's recent progress, in a mechanical point of view, is its inclined plane system. Being situated in a small "cove" of the hills, at least two hundred feet below the general level of the surrounding country, the city early felt the inconvenience of a crowded site and a sooty atmosphere. In consequence, numerous suburban communities grew rapidly upon the higher lands and extended for many miles in various directions. Thus the problem of easy access assumed great importance, in view of the incapacity of horseflesh to answer the growing demand for quick transportation up the steep hillsides.

The steam inclined plane has solved the problem satisfactorily, and it is now but a question of time as to when the city proper shall be wholly given up to business, and the hills utilized for residences. The city has now four planes in constant operation, with others projected but not built.

The history of this enterprise is interesting, it being the pioneer of the system.

It was commenced in the latter part of 1871, at the suggestion and under the superintendence of Mr. J. M. Doherty, who was associated in the ownership with Messrs. Geo. A. Smith and J. Stacy Hill, and completed and opened for business March 12, 1872. Nearly one million passengers were carried the first year, and the number in each succeeding year has not decreased. It is a remarkable fact that in the six years of its existence and constant use not a single casualty has occurred—a record all the more important in view of the disfavor with which the experiment was regarded by engineers and the press in its early stages, and the prediction of "a great horror sure to occur."

The plane itself is a trestle upon which is laid a double

track of the ordinary T rails, with "fish" joints, upon which cars descend and ascend alternately, drawn by wire ropes from above. It is 842 feet in length, starting at the bottom at an inclination of 32 feet in 100, for about 100 feet, then continuing throughout at a uniform inclination of 26 feet in 100. Through the courtesy of Mr. Doherty and of the chief engineer, Mr. Davis, we made a careful examination of the machinery employed in elevating the cars, and the appliances for securing safety, which are entitled to a brief description.

Steam power is generated in two cylinder, double flue boilers, 42 inches in diameter and 24 feet long, only one of which is ordinarily used. These supply steam to two reciprocating engines operating the same shaft, with 12x24-inch cylinders and valve and reversing gear of the ordinary link-motion type. A gear wheel upon this shaft meshes with the teeth of a similar gear in the center of a large double wooden drum 9 feet in diameter and 12 feet long, about which the wire ropes attached to the cars wind and unwind alternately—each half of the drum being occupied by a rope from one car, so that the operation of drawing up one car lowers the other. By passing the ropes over sheaves rotating loosely upon a horizontal screw-threaded shaft the side travel of the ropes upon the drum is regulated. Strong sheet iron bands passing around the periphery of the drum, and contracted by a double crank movement below, form powerful brakes to control its motion, and, with the other machinery, is managed by the engineer, who stands at the head of the plane and operates everything according to the exigencies of use. The estimated power of the engines combined is seventy horse. To insure perfect safety an additional wire rope is attached at its ends to the two cars, and passes around a large horizontal sheave at the head of the plane. The journal bearings of this sheave are set in a system of levers so arranged that in case of breakage of the main ropes from any cause the weight of the cars upon the auxiliary rope at once draws the sheave into a wedge-shaped circular brake shoe, and operates an independent brake in addition, by which the movements of the cars are instantly and automatically controlled.

The machinery was designed and the safety appliances invented by Mr. Isaac V. Holmes, and the whole built by Jos. Cooper & Co., Mount Vernon, O. So perfect was the design and the execution of the work that no change has been found necessary in either except the renewal of minor parts from ordinary wear. The perfect ease with which the machinery is handled no doubt has contributed greatly to the record of safety.

The successful establishment of the inclined plane began the new era in the history of Cincinnati, and on a summer evening one may now meet thousands of pleasure-seekers at the hill-top resorts enjoying the extended prospects and cool refreshing breezes of the elevated heights, with the magnificent panorama spreading out below.

The foregoing particulars are from the *Western Inventor*. The accompanying drawing of the new Highland House, Cincinnati, O., Mr. G. W. Rapp, architect, is from the *American Architect and Building News*. (See page 1905.)

The Highland House was built in the summer of 1870, is at the head of the Mount Adams and Eden Park Inclined Railway, and is a species of *casino*, which is used for a restaurant and for balls, banquets, etc. In the basement are the kitchen, 18x30 feet, laundry, ice-cellars, bowling-alleys, etc. The plans show the arrangement of the other stories.

IMPROVED FIRE-ENGINE PUMP.

It will be seen by the section (Fig. 2) that the arrangement is simple and compact—desirable qualities in a pump for general purposes. No leakage can take place, as the tumbler-shaft is between the two buckets, which are fitted with cupped leathers, and therefore work tighter in the barrel the greater the pressure becomes. The valves are arranged in such close proximity to the ends of the barrel that the waste space is reduced to a minimum. The valves are also easily got at, in case of clogging, by merely slacking a few nuts, when, as shown by the engraving, the suction and delivery valves are both exposed, and the plunger can also be withdrawn from the barrel. These advantages are due to the fact that, instead of there being separate barrel and valve-box covers, the end covers are made to answer both purposes. The valves, which are of the ordinary flap description, can be taken off, for renewing a leather, by merely slacking a set-screw, and as easily replaced, while the cupped leather of the plunger can be replaced in much the same way and with no greater difficulty. Another feature of this pump is its easy working. Instead of a long, painful stroke, some part of which must be made at a disadvantage, a short, rapid motion is employed, exerted by the worker in such a position as to insure a direct application of his power at the best advantage. The fact that these pumps have been worked with 30 feet of suction hose proves their power and efficiency. Besides the two covers containing the valves, there are really only two other joints that need be made, viz., that of the suction pipe and that of the air-vessel to which the delivery pipe is attached. The tumbler-shaft has no need to work in a stuffing box, being placed between the buckets. This pump, which is a stock article with Messrs. Duvallon & Lloyd, Birmingham, Eng., is made in six sizes, from 2½ inches in the barrel, lifting about 300 gallons an hour, to 6 inches, lifting 1,400 gallons. It answers equally well as a force pump, and is admirably adapted for farm purposes generally.

The fire-engine, shown at Fig. 1, is of exactly the same construction as the pump; but a 6-inch barrel is generally adopted, and the longer double handles admit of a greater power being applied. Mounted on a truck for ready shifting from place to place, this handy arrangement is well adapted for ships' decks and factories, as well as farm-yards, and, with a sufficient supply of water, may be the means of arresting many a fire in its earlier stages.—*Iron*.

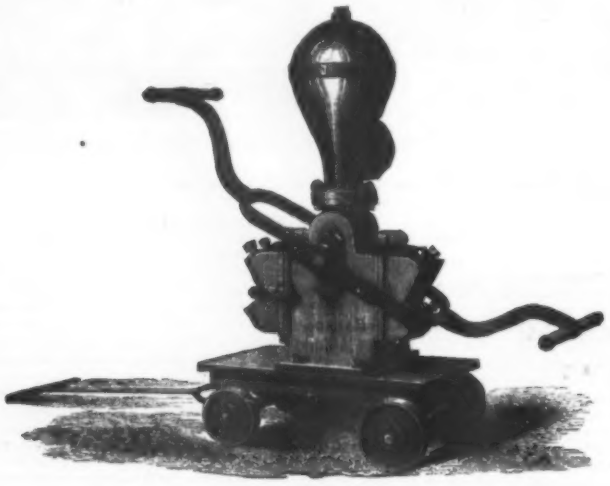


Fig. 1.

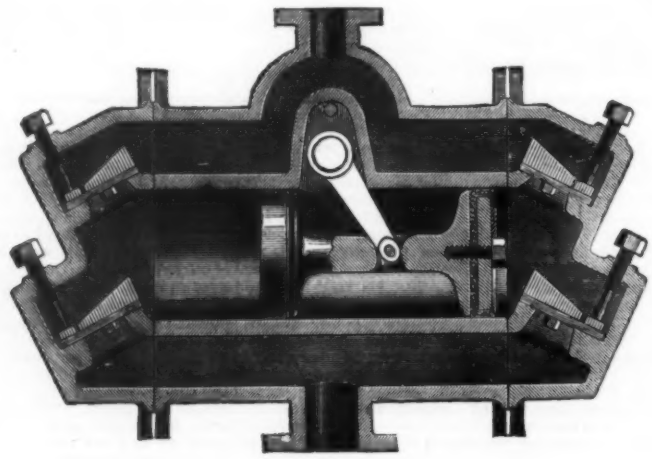


Fig. 2.

IMPROVED FIRE-ENGINE PUMP.

COMPRESSED AIR RECEPTACLES.

In constructing vessels intended to resist great internal pressure, such as hydraulic cylinders or accumulators, receptacles for highly compressed air, shells of locomotives, or other high-pressure boilers, the metal should, according to the invention of Mr. C. W. Siemens, of Westminster, be put into such a form as to combine strength and toughness to the utmost degree, and jointing by screws, rivets, or welds should be avoided. For this purpose he casts or forges masses of mild steel or of iron in the form of rings, which are subjected to circular rolling, as in the manufacture of wheel tires. Rings of metal are thus produced with a low projecting flange at each end, which is faced in the lathe, and has one or more V grooves turned into the face. Each flange is also turned on the back, slightly tapering so as to be thinnest at the outer edge. The rings so prepared may be put face to face, with caoutchouc or other soft packing material or cement between them, or with rings of copper or other comparatively soft metal laid into the V grooves. The faces are then pressed together by means of a ring of steel or iron, with an internal groove turned or rolled therein so as to fit over the projecting flanges. This ring is put on in halves and closed by means of screw bolts or otherwise, and thus the two flanges are drawn tightly together, and are held permanently in that position. Any number of rings may be thus joined together so as to form a continuous cylinder, the ends of which may be closed by strong flat or dished end plates, joined to the cylindrical portion by clip rings as described. The rings may be rolled conical, so as to produce a vessel of tapering form, and the flanges may project inward and be clipped by internal rings divided into two or more parts forced outward by wedges or screws.

In constructing hydraulic accumulators in this manner the end ring is rolled into such a form as to admit of the introduction of a cup leather or other packing. The plunger may be constructed, as above described, of rings of internal flanges and turned on the outside to give a smooth working surface. In constructing hollow cylindrical vessels intended to resist blows, such, for example, as cylinders for the protection of riflemen in the field or for protecting cannon, he prepares rings composed of two descriptions of metal, the one being possessed of great toughness, and the other of hardness. For this purpose he casts or forges a ring of mild metal, which may be steel or iron, and placing the same in a circular mould while in a heated condition, he pours into the mould cast-steel containing considerable percentage of carbon—say from 1½ to 1 per cent., according to the degree of hardness required. While the cast metal is setting and contracting, the inner ring is cooled by currents of air or sprays of water directed against its inner surface, so as to allow the outer metal to shrink without cracking, or for the same purpose the inner ring may be divided longitudinally. The two metals are thus intimately united or welded together, forming a composite ring which can be rolled out to the requisite thickness and diameter, with internal or external flanges or grooves for connecting several such rings together as already described. In producing in this manner thick rings for the construction of turrets for the protection of cannon the rolling may be dispensed with. For armor plates he adopts the same method of combining metals of different tempers by pouring the harder metal in the fluid condition upon the metal of milder temper.

Plates may be made to consist of several alternate layers of these different metals by placing in the mould into which the harder metal is poured several parallel plates of the more ductile metal. By directing a gas flame into the mould, these plates may be heated sufficiently to prevent cracking of the harder metal in setting, but the risk is also greatly diminished by dividing the plates by cross-cuts or deep incisions. Ingots or slabs are thus produced, which when hammered or rolled will be found to resist the penetrative action of projectiles in a remarkable degree. Their resisting power may be increased by hardening the surface of the finished plate by subjecting it while red-hot to the action of a spray of water. For producing shells or hollow shot of composite metal, he prepares a hollow core of iron or soft steel, and placing it in a heated condition in the mould, he pours over it the harder metal, taking care to cool the interior of the core while the outer metal is setting and contracting. The composite projectile thus produced is afterward heated and forced by hammering or pressure into a metal die, so as to condense the material of its head and outer surface, which may be hardened by sudden cooling.

THE WORKING OF COAL.

THE PARALLEL MULTIPLE WEDGE EXPANDER, ETC.

As the use of gunpowder in most of our collieries is attended with more or less danger, and in many districts is altogether prohibited, owing to the fiery nature of the mines, various substitutes have been brought forward to take its place. Some of these have acted tolerably well, but with scarcely that amount of success that could be desired. So far back as 1864 Mr. C. Bartholomew, of Doncaster, patented an invention for bringing coal down by hydraulic pressure and levers, or turning bars. By one arrangement a hole is drilled in the coal, and the far end enlarged when a steel or iron rod is introduced, the far end of the rod being of the diameter of the hole, and made like the frustrum of a cone whose height equals the height of the conically enlarged part of the hole. The rod being then introduced to the full depth, the whole of the space between the sides of the hole and the solid rod is rammed full with damp coal dust or other material and made thoroughly solid, and then a lever combined with a jack or hydraulic power or otherwise is brought to act upon the rod, so as to wrench out the coal. Or a worm made on the outer end of the solid rod, with a nut on it working against a spring, spring-bar, or frame, the ends of which rest or are supported against the face of the coal at points a proper distance from the hole, and the nut being worked by handles, levers, or otherwise, the rod is drawn outward and with it the coal. The invention of Mr. Bartholomew, who is a large colliery owner as well as a civil engineer, we believe was tried in South Yorkshire with most satisfactory results, but nothing has been heard of it for a very long time, and the probability is that the patent has been abandoned.

The next in the field was Mr. Grafton Jones, whose patent is dated June, 1867, and which we have seen in operation. It consists of a disk of iron 7½ ins. in diameter and 2 ins. thick, with hydraulic ram, etc. A nick being made vertically in the coal, the disk is inserted, fitted with a cup-leather, forming a hydraulic ram, with a stroke of ¾ in. To the hollow disk or cylinder a pipe is attached, serving as a handle, by which it can be inserted into the nick, and this handle is continued by means of a flexible pipe to a force pump, drawing its water from an airtight reservoir, and worked by one man. By the action of the hydraulic ram the coal was broken from the solid, and its removal thus facilitated, the airtight reservoir serving to draw the water back from the ram cylinder on the completion of the stroke, thus pulling the ram into its place, and enabling the same water to be used over again.

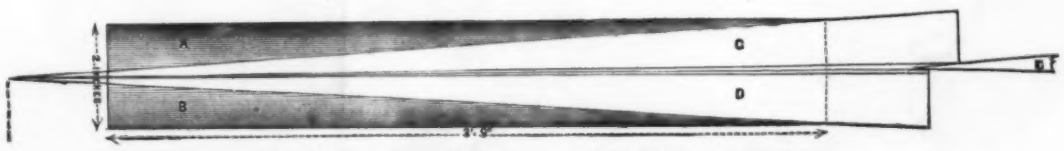
Next in succession appears to be the machine of Mr. John Chubb, patented in May, 1868. The principle of the machine consists of wedges ingeniously arranged, by which any degree of expansion can be obtained, but the expansion is not parallel. Instead of forcing one solid wedge between the pressing blocks, two wedges laid side by side, so as to look like one wedge split down the middle, are forced in, and then, if more expansion be desired, the ram can be drawn back, the press removed, and the point of another wedge inserted between the heads of the split wedge; the press is then reattached, and this second wedge forced in, an operation that can be repeated as often as required.

In 1868 Mr. Bidder, of London, also took out a patent for a machine for bringing down coal, which was for some time in operation (if, indeed, it is not at present) in the Harecastle Collieries, near Stoke-on-Trent. The machine may be described as a screw 4 ft. 6 ins. long and 1¼ in. in diameter, feeding itself through a fixed nut at the rate of six turns for 1 in. advance, and carrying a steel spiral 16 ins. long, formed at the end into the shape of an auger 4¾ ins. in diameter. An ordinary ratchet brace is used for turning the screw. The nut is carried on a flat bar of iron, one end of which is round, and which is inserted into a hole in the coal for a depth of 8 or 10 ins., the strain on the nut keeping the bar firm. The cutter can be easily removed from the bar when it is desired to draw back the cutter to clean the hole or when it is completed. The nut device has been found to act very well in thick seams of coal, where the roof is bad.

The most recent invention, however, for bringing down coal effectually and economically is that patented by Mr. G.

W. Elliott, of Chowbent, near Manchester, and of which Mr. Macdermott, of London, the patentee of the coal perforator, is the agent. It is a most effective instrument, and is known as the "Parallel Multiple Wedge Expander," and not only brings the coal down after it has been holed, but without the latter process, by forcing it toward a loose end. The wedge is made of the best quality of steel, while its power of expansion is almost unlimited, and as the work can be carried on without any break whatever, it brings the coal down in less time than is required in blasting. A short time since some interesting experiments were made with the wedge at the extensive collieries of Messrs. Wood & Son, Scot Lanes, Blackrod, and West Houghton, in the Wigan district, in the presence of a considerable number of practical men, who were much struck with the simplicity of the invention, its lightness, and moderate cost. Mr. Elliott, the patentee, conducted the experiments, along with whom was Mr. John Unsworth, the manager of Messrs. Wood & Son's pits. The first trial was made in what is known as the "Yard Mine," a seam of coal about 30 ins. in thickness, worked on the longwall principle. The place selected was where the roof was of a rough scaly nature, so that even powder could scarcely operate successfully on it. The coal was first holed or undercut to a depth of 3 ft. 6 ins. and 8 yards in length, and then a hole for the insertion of the wedge was drilled by Macdermott's patent "rock perforator" in a very short time near to the roof. The point of the wedge was then inserted in the tool, and two other parts were also put in and driven home alternately by a sledge hammer. The result was more than any of those present anticipated, for the coal came down very clean, and in a very large quantity, in marketable condition. A second wedge was at hand as a reserve in the event of the first one turning out to be unequal to the work required, but which it was stated was very seldom the case. The next trial was on the roof of the same pit, which is generally brought down with some difficulty. But here the wedge did what was required of it most effectually, for it brought down a vast quantity of stuff in a comparatively short time, much greater, indeed, than could have been obtained by blasting in the ordinary way. The apparatus was then taken to the well-known Arley seam, where operations were commenced in the "wide-work," the bed of coal being 44 ins. in thickness. The seam was holed about 3 ft. 6 ins. in depth and 12 yards in length, when the wedge was inserted as previously described, and with the most satisfactory results. Mr. Elliott then undertook a still more trying operation, attended with more than ordinary difficulty. He applied the wedge to some very hard and solid rock, and in seven minutes he pierced through 20 ins. of it, a task which under ordinary circumstances and by the usual appliances could not have been accomplished under a couple of hours. This was considered by those present as a really excellent performance, and fully bore out all that the patentee had said could be effected by his invention. A few days afterward a third trial was made in the Arley seam at another pit belonging to the Messrs. Wood, where the coal was worked on the "pillar and stall" system. The wedge was put in operation in a pair of "down brows," and driven on the face of the coal. These places were 12 ft. wide, and the coal having been holed and cut on one side the wedge was put in on the opposite side of the "cutting," about 1 ft. from the roof and about the same distance from the side. The effect was very soon seen by a large fall of coal with very little slack—a most important object. Indeed, the result of the experiments showed that a far less quantity of slack was made by the wedge than by blasting with powder, the extra quantity of round coal being fully equal to 10 per cent. The principal work involved is that of driving home the wedge, which is considerable, but the manager of the colliery states that the results of the trials made show a saving in coal by bringing it down in a marketable state, and safety from explosions of gas caused by blown-out shots. The wedge can be used in a hole 2¼ ins. in diameter, drilled if necessary in the ordinary way, but the use of Macdermott's patent coal perforator is recommended for the purpose, on account of the time saved and the greater amount of coal brought down—effects due to the straightness and uniformity of the hole drilled.

It has been found with respect to the various modes of bringing down coal by wedges that more coal is got by them than with powder, so that a given area of coal can be worked at a much cheaper rate than by blasting. The parallel multiple wedge expander is a most powerful and effective instrument, and we hope before long to be present on the occasion of its being tested in a different part of the country, so as to make known the results of our observations on a mode of bringing down coal that cannot be otherwise than of interest to our colliery proprietors.—*Mining Journal.*



ELLIOTT'S IMPROVED MINING WEDGE.

The parts A, B, C, and D when together, form a round bar 2 inches diameter.

The mode of working is as follows :—The portions of the wedge marked A B are inserted in the tool, then the parts B and C are alternately driven home, and then the coal comes down.

[ENGINEERING AND MINING JOURNAL.]

MINING IN BOULDER COUNTY, COLORADO.

By F. L. VINTON, Mining Engineer.

THREE counties of Northern Colorado, lying on the base of the Rocky Mountains toward the east, are justly famed as one continued labyrinth of valuable metallic mines. Two great belts of fissures carrying ore run through these counties N.E., S.W., nearly vertical, in solid walls of gneiss and granite, with gangue of flint, talc, and all the spars. The southern belt is characterized by gold and the telluride or selenide of that metal, the northern by native silver and its various ores; they are parallel to each other, and contiguous, but distinct, although at their zone of contact they give mines that furnish both the precious metals. Gold and gold ores are not usually so regularly distributed in their veins as silver and its combinations, wherefore opinions may differ upon the comparative value of the two kinds of mines; but there are enough of both in Boulder County to satisfy various tastes, and the indifferent may well hesitate in admiration between the lumps of Caribou silver on the one hand and the gold of Sunshine on the other. If, of the three counties, Boulder, Gilpin and Clear Creek, the first be not the richest, it certainly surpasses in variety of mineral wealth, and transcends all in picturesqueness. The scenery of Boulder Cañon is made up of stately crags, well timbered with pine and cedar down to a torrent below. It merits the guide book epithets "sublime" and "beautiful."

Boulder Cañon and its tributaries' cañon routes into the mining regions are not yet subjugated to the rail, but on the excellent roads that thread them all are seen each day the traditional stage coach and elegant modern vehicles, mingled with the characteristic ore wagons, these last laden, when coming down, with about two tons each of mineral, worth sometimes a thousand dollars per ton.

A ROAD PAVED WITH GOLD AND SILVER.

From the plains of Boulder up to the head of these gorges the way is, in fact, paved with gold and silver, but not to be gathered by stooping unless with pick or drill. This warning is on the road at every step, for the mountain sides are burrowed with tunnels and prospect holes, some worked, some abandoned, but all the sign manual of labor. The traveler sees not a hundredth part; an invisible mining population swarms in every direction and delves incessantly. One would sooner call their perforations innumerable than attempt to number them. Of the many active and successful mines, I can only at present mention a few, beginning, naturally, with those near Caribou at the head of the cañon. These magnificent silver mines are, in great degree, familiar to the public, through the comprehensive *résumé* and capital illustrations of them published in the *Engineering and Mining Journal* of August 11, 1877. At the present date there is even more movement prevailing in them than then, but, as ever, the unrivaled silver producer of the district is the celebrated Caribou Mine with its adjunct mill, both operated under the direction of a most able superintendent and cordial gentleman, Mr. Eben Smith. The mill is amalgamating, but contains also a plant for leaching, which will be used when pyritous ore are more plentiful than now in the vicinity. Caribou Hill is blistered with dumps, and riddled with shafts, drifts and tunnels; among these last works of mining art, the Consolidated Caribou-Belt Tunnel is of the handsomest, and most happily located. It pierces the contact zone of the two great belts, and has already cut three valuable lodes of free gold and silver ore. Its projected length is three thousand feet, and its face is seven by seven, but run, as it is, with the Wood drill, the favorite power-drill here, it will not be tardy in reaching the numerous other well-known veins to which it is aimed. No enterprise is more to be recommended in our mountains than a sound tunnel project; a tunnel claim in Colorado is three thousand feet in length by fifteen hundred broad, and on this width it possesses all the lodes it intersects except those previously claimed, recorded and worked in proper form. In many cases those also might preferably work through an advantageous tunnel on royalty, rather than by their shafts, for a tunnel is the best kind of working adit on a real lode, though bad for prospecting into a veinless mountain, as we sometimes find here.

THE SANTA LA SARIA MINE.

The silver mill at Nederland gives the life to that pleasant little hamlet that steampipes and smokestacks always bring, while there, too, they hardly can dispel the romance of environing nature. A short distance from Nederland is the Santa la Saria Mine, lately leased by Scheyer & Co., large reducers of ore in Denver. It is now started up in full force under the direction of your correspondent, and will be developed continuously with two shifts, and stoped as fast as convenient. This mine produces exceedingly rich ore, excellent for leaching, and has just struck a rich chimney of gray copper 18 ins. thick. Adjacent to the Santa la Saria is the Washington Avenue Mine and mill. The activity there at this moment is in the mill alone; it is leaching a rich dump, and with profit, I believe. Certainly so handsome a mill deserves success. In that neighborhood, too, are several promising mines yet in infancy. Among these the Mayflower will bear mention; fine ore is to be seen in its shaft.

Near here commences Pennsylvania Gulch, on which is the Centennial Mine of free gold, now putting up stamps.

THE GOLD MINES OF BOULDER.

The gold mines of Boulder sustain their fame. There can be no doubt that some of these are extraordinary. The Smuggler, for example, has produced fabulously-rich ore, and with remarkable regularity. There are leases on that mine to-day paying 55 per cent. royalty. The Golden Age Mine, adjacent, is running stamps on rich ore; the float of that fissure gave last summer some of the finest specimens of free gold I have seen in quartz. The great American Mine, under our skilled and learned friend, Professor J. Alden Smith, seems in the way of absorbing some of its neighbors. The expansion of such mines as the American, typical in conduct and success, is proper and beneficial to all; it takes the country out of the narrow sphere of mere prospect mining, and exhibits the advantage of large methods and wide combinations. Great production is the very basis of economic exploitation. Boulder County has mines of copper, but none of the State are as yet appealing for description. Neither have I had occasion to examine the numerous and rapidly-developed coal banks of this favored county; the maps of the mines that I have seen represent a thoroughly good system of mining, and I am aware that the extraction of coal is extensive, increasing, and remunerative.

COST OF MINING.

Mining here is now, to a great extent, done by contract, tunnels, shafts, and drifts universally so, at prices ranging from $8 to $20 per foot. Stoping is sometimes contracted for by the fathom, at from $10 to $18. Forge work, ore sorting, and most outside business is paid by the day at from $2 to $3. The companies furnish all mining supplies, charging use and waste. Men are boarded handsomely by some good wife at the mine for $6 per week.

When we have dressing mills in Boulder County, concentrating for $3, and at not more than 20 per cent. loss, as I believe quite possible, our properties will double in value. For simple concentration of our silver ores, it is believed that crusher rollers and Rittinger tables are about the best; at any rate, we cannot stamp them, because their slimes elude all our machinery up to this time. Slime washers are said to work well on our gold ores. I have had no opportunity to judge of that, but I have discovered that the true way to obtain a clear view of most mining matters is to study them purse in hand.

Boulder County has ranch land on the plain, and many picturesque little ranches nestled about in the mountains. Here, too, is the site of the State University, and a good place for a school of mines, were it not that any professor worth miners' wages would soon be out of it and in better business, but for those who like a strong dash of the practical in theirs we can recommend our existing institutions, where a good, sturdy student can get two dollars and a half a day and take a first-rate four-years' course of passing dirt the first, sorting ore the second, turning drill the third, and, fourth, swinging the striking hammer for a *projet*. Of assayers and surveyors the country is full, and as it has already been well nigh ruined by fancy metallurgists, there is no wild call for them.

BOULDER CITY.

The city of Boulder is the depot of two railroads, the Colorado Central, and the Denver, Pacific and Boulder Valley Branch, each connecting with the Union Pacific R. R. at Cheyenne on the north, and with Denver on the south, some forty miles away; freight to Denver from Boulder is two dollars per ton; freight in the mountains would be comparatively cheap if the State would raise the toll; but the railroads will soon do that. A special benefit to the many mines of Boulder County will be the Boulder Midland and Central Railroad. Our hopes are strong that Prof. N. P. Hill will lend his weighty influence to that project, for it would insure its construction and create another real artery to Denver, which city will undoubtedly be the heart and capital of the State. Boulder is a handsome city, with fine residences, hotels and business centers, and always presents a very spirited air. Like all the cities of Colorado, it is kept with good order, good manners and good sense. I do not believe there is another State in the Union where the inhabitants, as an entirety, and particularly as a mining population, are so well educated and generally so seemingly well bred as here. The city of Denver, above all, is charming in society and surroundings. She is fated to become a metropolis, yet let her not waste time in emulating Paris as a caravansary for wayfarers, or Nice as a hospital for invalids because her climate is unsurpassed, but anchor to the mountains with an iron grip, draw their gold and silver to her refineries, and let the rich and beautiful passes of Boulder County be the next tributaries to her growth.

IRON AND COAL IN BRITISH COLUMBIA.

NANAIMO and Comox are not the only known coalfields of Vancouver Island. Coal occurs, and was worked at one time by the Hudson Bay Company, near Fort Rupert, on the north-eastern coast of the island. A low, flat country is reported to stretch from here to Quatseno Sound on the west coast, where the coal rocks are again known. Some examination of the latter locality was made at one time for an English company, who had acquired property there, by Mr. Landall. Mr. R. B. Brown, the botanist, also visited the region in 1866, and writes regarding it:

"My opinion is decided that the Koskemo (Quatseno) coalfield is the best yet discovered in Vancouver Island, though unopened out, not only on account of the superior quality of the coal, but the ready accessibility of the mines from the Pacific, without the inland navigation requisite for reaching the mines on the eastern seaboard of the island."

The main seam is stated by Mr. Landall to be about four feet six inches in thickness, and the quality of the coals, as shown by his analyses, is good. He estimates the coal of the part of the Quatseno basin he examined, making allowance for faults, etc., at 33,600,000 tons.

Mr. Richardson also describes the occurrence of rocks of the coal series at the head of Alberni Canal, opening into Barclay Sound on the west coast. Specimens of coal have been procured there, but the mode of its occurrence is not known, neither this locality nor those on the northern part of the island having yet been examined by the Geological Survey.

The interior of Vancouver Island being comparatively unknown, even in regard to its main topographical features, it is not improbable that a geological examination may bring to light coal-areas, which may be extensive and important, in the valleys of the interior. A considerable part of the crumpling and metamorphism of the older rocks is of a post-cretaceous date, a fact which renders it quite possible that outliers of the coal-rocks may be found folded into other synclinals besides those already known along the coast-line.

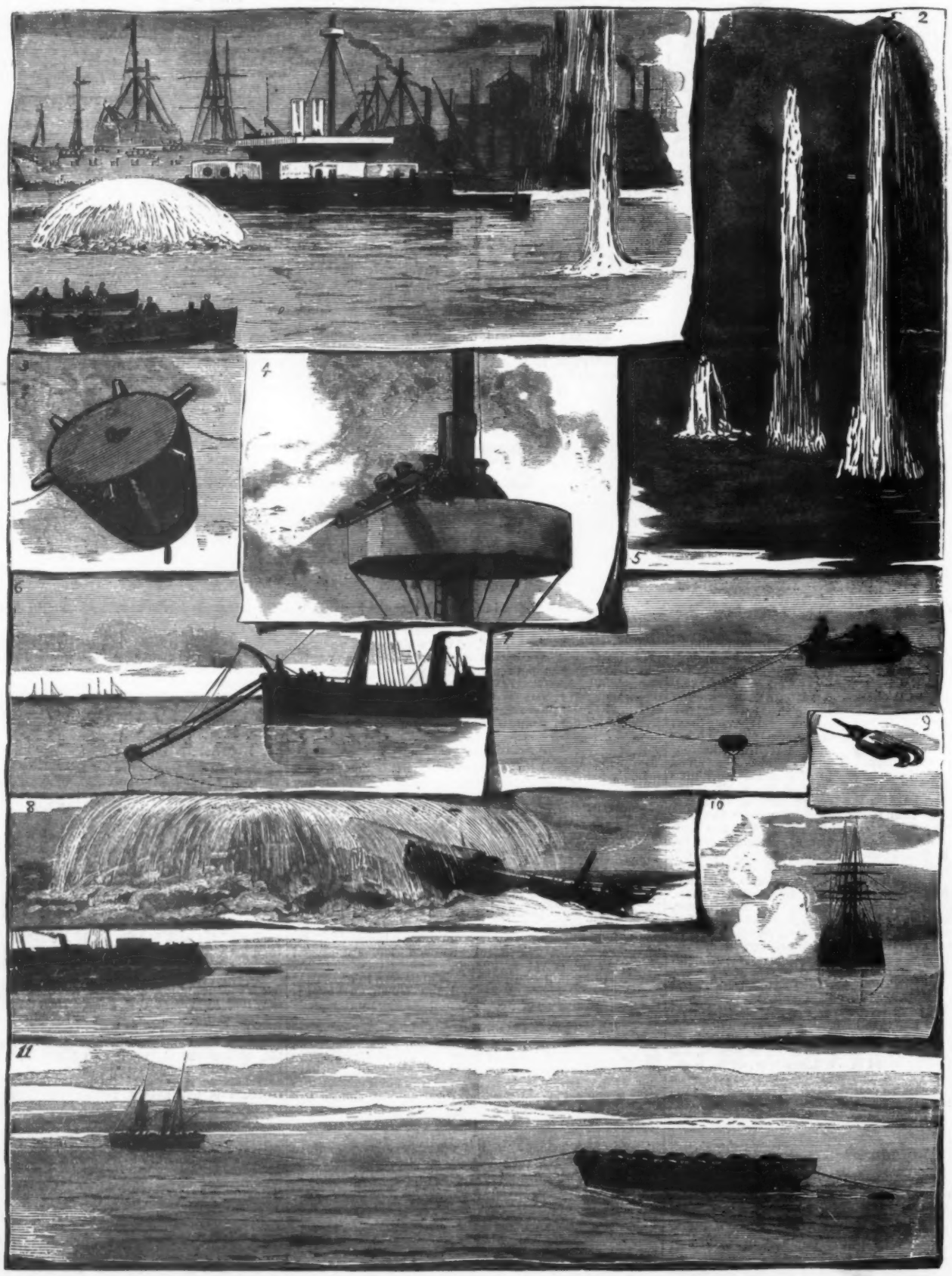
The question of the possible occurrence of coal-bearing rocks of the age of those of Vancouver Island on the mainland of British Columbia is one on which little can be said. The equivalents of these rocks have not yet been distinctly recognized, nor is it known whether it will eventually be possible to separate them by any well-marked line from the lower rocks of the Queen Charlotte Islands and their representatives on the mainland.

The coast sections of Vancouver and Queen Charlotte Islands will probably afford the means of determining the relations of the two series.

RECENT TORPEDO EXPERIMENTS IN ENGLAND.

In England at the present moment the most active preparations for a prospective war with Russia are going on, and so far as naval operations are concerned the torpedo system is likely to be brought into more extensive use than ever before.

Recently a visit was made to Portsmouth Dockyard by the Speaker and some hundred other members of Parliament, entirely unofficial, the visitors having been invited by Lord Charles Beresford, M.P., Commander of H. M. S. Thunderer. Our cut and these particulars are from the London *Graphic*. Traveling from Victoria Station by special train, the party were received at Watering Island Jetty by Admiral Foley, Chief Constructor Robinson, and other officials. After crossing the dockyard in some open railway trucks drawn by a dockyard locomotive, they went successively on board the Inflexible, the Dreadnought, and the Thunderer, all turret ships of the latest type. The first-named of these vessels, about the stability of which there has been so much controversy, will probably be completed within the year. Her tonnage is 11,406, her horse-power 8,000, and she will throw about twice the weight of metal of any other English ship. The Dreadnought is much nearer to completion than the Inflexible, and, as her turrets are finished and armed, the visitors had an opportunity of seeing how easily heavy guns can be worked by machinery. On the quay alongside the Thunderer 650 lads from the St. Vincent training ship and 300 seamen gunners from the Excellent were drawn up for inspection. The visitors then went on board the Iris, a steel clipper, and the Glatton, a ship of the enlarged monitor class, after which the Speaker and about a score of guests were led off to the residence of Admiral Foley to luncheon, while the remainder of the company was received on board the Thunderer by Lord Charles Beresford and Captain Wilson, his commanding officer. After luncheon the Thunderer was eagerly inspected, and visitors ascended the flying deck and breastwork deck to witness the evolutions of the crew, who, under the orders of Captain Wilson and Lord Charles Beresford, evinced remarkable smartness in clearing the impediments, such as stanchions, catheads, boats, davits, etc., removing the glass illuminators from the deck and substituting armor coverings, and beating to quarters in readiness for an engagement, all being completed in three or four minutes. A Gatling gun was hoisted in the tops, whence it would sweep an enemy's decks. The turrets were revolved and the guns worked, all being done in a manner that elicited the warm encomiums of the visitors. Attention was next directed to the Vesuvius torpedo vessel, Captain Morgan, lying just astern, beside which was a dingy, from which a Whitehead torpedo was dispatched in the direction of a boat some distance out in the basin. Next, a launch, with no one on board, and steered by electricity, left the Vesuvius, and dropped two counter-mines, which were exploded from the Vesuvius. Illustration was also given of the method of clearing channels of torpedoes and other obstructions. On leaving the Thunderer the visitors went in steam launches to the Vernon torpedo school-ship, Captain W. Arthur, where a lecture on torpedo warfare was delivered by Commander Wilson, experiments were made to show the effect of gun-cotton in various states, and a boat was sent from the ship with spar torpedoes, which were fired by electricity.

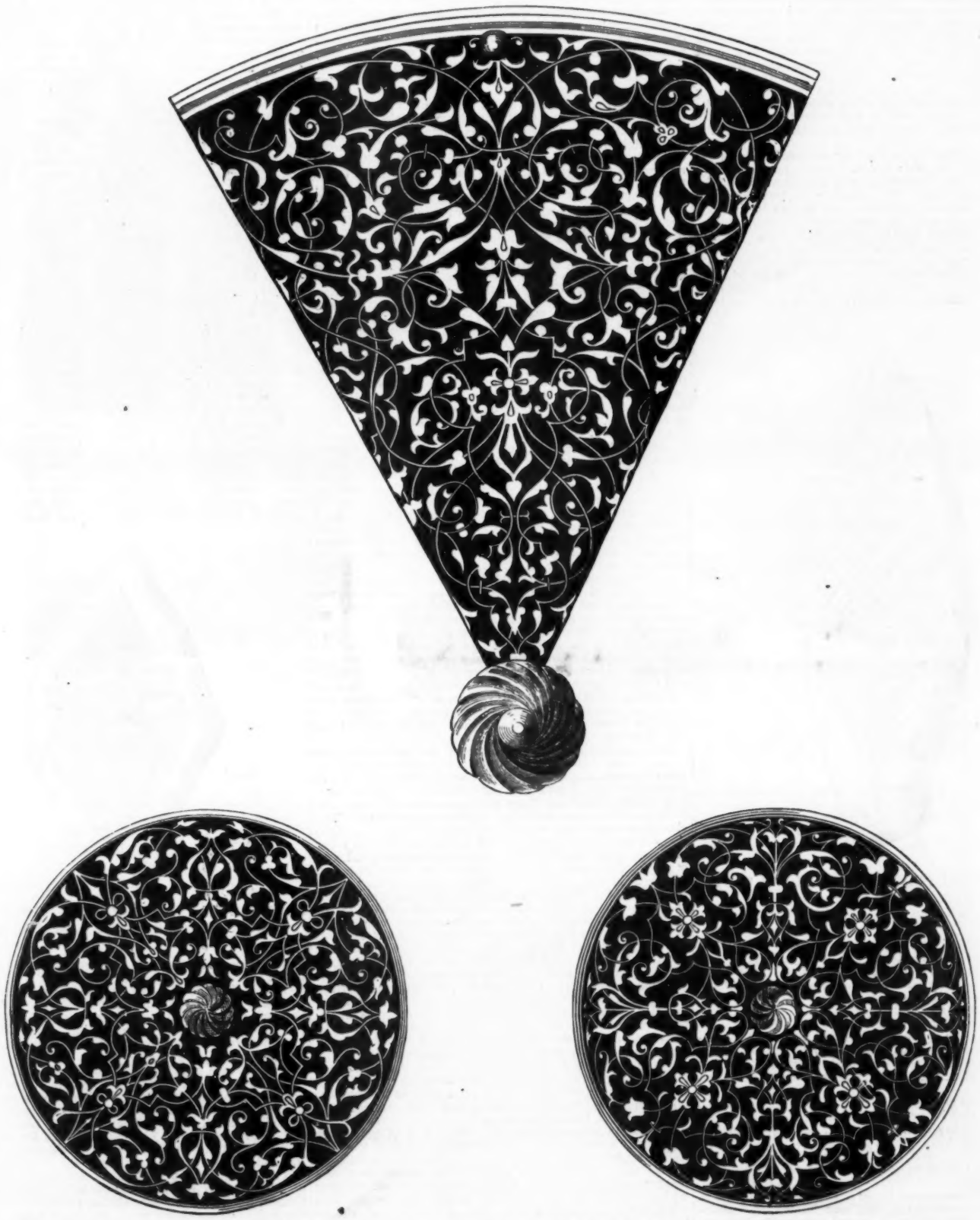


RECENT TORPEDO EXPERIMENTS IN ENGLAND.

1. Watching Experiments from H. M. S. Thunderer.—2. Mine Elploded, a Cask thrown to a height of 200 feet.—3. A Russian Torpedo captured by the Turks.—4. Gatling Gun on the Mast of H. M. S. Thunderer.—5. Exploding Sunken Mines.—6. Torpedo Fender Catching the Enemy's Mine.—7. "Creeping:" Fishing up the Electric Wire of Enemy's Torpedoes to blow them up. "I've got a bite; pull away, my lads."—8. Spar Torpedo Practice: a Ducking at Close Quarters.—9. Grappler Loaded for destroying Torpedo Connections.—10. H. M. S. Vesuvius discharging a Whitehead Torpedo.—11. Boat Steered by Electric Cables dropping Torpedoes to clear the Waterway of Enemy's Sunken Mines.

DAMASCENED ORNAMENTS FROM A SHIELD, HISPANO-MORESCO WORK.—SUGGESTIONS FOR DECORATIVE ART.

THIS is a round shield made in wicker work, covered with stuff and mounted with seven steel bosses of conical form, a large one rising in the center, six smaller ones being ranged around. All these bosses are richly ornamented with beautiful arabesques damascened with silver, an artistic process characteristic of Hispano-Moresco ware. Based on good old models, the traditions of this process were to a certain degree still preserved in Spain, where great efforts have been made in late years to revive it, and crowned with complete success. The original is in the "*Armeria*" Collection in Madrid, the engraving made from a photograph by J. Laurent.



SUGGESTIONS IN DECORATIVE ART.—DAMASCENED ORNAMENTS FROM A SHIELD.—*From The Workshop.*

PRIZE FOR BLOWPIPE APPARATUS.

IN May last, a prize of £10, which was placed at the disposition of the Council by Col. A. A. Croll, was offered by the Society of Arts, with the Society's Silver Medal, for the best set of blowpipe apparatus which should be sold retail for one guinea. The conditions were that the apparatus should, at least, contain blowpipe, blowpipe lamp or candle, spirit lamp, charcoal or charcoal pastilles and holder, platinum wire, glass tubes closed at one end (matrasses), open glass tubes, platinum-tipped forceps, magnet, hammer and anvil, and four reagents, viz., borax, microcosmic salt, carbonate of soda, and nitrate of cobalt. These instruments and reagents, together with any others which might be thought desirable, were to be packed in a box. It was assumed to be understood that the above list of apparatus, etc., was only intended to include such as are absolutely indispensable, and it was expected that the set would contain additional instruments and reagents, the selection of which was left to the competitors.

Special attention was called to the following points:—1. Solidity of construction; 2. Compactness and portability; 3. Facilities for packing and unpacking; 4. Number of useful instruments and reagents, in addition to those mentioned.

The apparatus for competition were to be sent to the Society's House on or before 1st August, 1877, and it was stipulated that the successful competitor should guarantee that a proper supply of the apparatus should always be kept on hand, for sale in England.

The following Committee was appointed to consider the award of the prize: Major Gen. F. C. Cotton, C.S.I. (Chairman of the Council), Mr. F. A. Abel, C.B., F.R.S., Dr. C. Le Neve Foster, Captain Douglas Galton, C.B., F.R.S., Admiral Sir Erasmus Ommanney, C.B., F.R.S., Mr. E. C. Tufnell, and Mr. Warington Smyth, F.R.S.

In response to the offer eleven sets of apparatus were sent in. These were all subjected to careful trials by Dr. C. Le Neve Foster, H.M. Inspector of Metalliferous Mines, and on his report the Committee determined that, though many of the sets showed great merit and considerable advance beyond what was previously obtainable for a guinea, no one of them showed such excellence as to justify an award to it of the prize offered. It was, therefore, resolved that a fresh competition should be opened among those who had already sent in, and a letter was addressed to each of the competitors, pointing out what the Committee considered to be the deficiencies in his set, and inviting him to send in a set of apparatus modified in accordance with those views. The date for the new competition was fixed for December 31st.

In response to this second offer, seven sets of apparatus were sent in, all of which the Committee consider to have shown decided features of merit. These were treated the same way as the former sets, and the Committee determined to recommend that the prize should be awarded to Messrs. Letcher, of Camborne, and St. Day, Cornwall. They also recommended that a second prize, consisting of a bronze medal, should be awarded to Herr Osterland, of Freiberg, in consideration of the great excellence of his apparatus, though they consider that the packing arrangements are hardly of a nature to stand rough usage.

The report of the Committee was lately received and adopted at the meeting of the Council.—*Journal of the Society of Arts.*

IN sketching the world's progress in meteorology, at the Munich meeting of the German Association, Dr. G. Neumayer ranked the United States first, England second, Holland third, France fourth, and Denmark fifth.

THE GEOLOGICAL ANTIQUITY OF FLOWERS AND INSECTS.

By J. E. TAYLOR, F.G.S., &c.

NO NATURALIST will deny that, in every period of the earth's palæontological history, the animal and vegetable kingdoms have been correlated, no matter how lowly organized they may have been. But if the geological record is imperfect as regards the *animal* life which has peopled our globe during past ages, none will be surprised that it should be considerably more so as regards extinct *vegetable* types. The chances are infinitely against the preservation of the latter in sufficient perfection to enable modern botanists correctly to make out their relationships. The earliest plants were formed of loose vascular and cellular tissues, which readily decomposed, and were therefore difficult of fossilization. Plants do not possess such hard and comparatively indestructible parts as the majority of animals have, as teeth, bones, tests and shells. Only a few plants have external substances capable of resisting decomposition, but such species rank low in the scale of classification, as in the case of the *Diatomaceæ*, which possess siliceous frustules or valves. The horse-tails (*Equisetaceæ*) are remarkable among plants by the large quantity of silica which enters into the tissue of their exterior; and in this respect they resemble many of the grasses, notably such gigantic species as the bamboo.

With the exception of the *Algæ*, or sea-weeds, plants are chiefly terrestrial in their habits. Even those flowering plants we call aquatic generally grow at the margins of the land or in shallow water. The number of true flowering plants, such as *Ruppia* and *Zostera*, which live in brackish or salt water is very few. Consequently geologists are dependent for the preservation of plants upon fewer physical possibilities than those which allow animal remains to be fossilized. Only where an extensive lake has had sediments quietly forming along its bottom, or in the estuary of some large and not too turbulent river, has it been possible for plants to be mineralized; and it is in lacustrine and estuarine

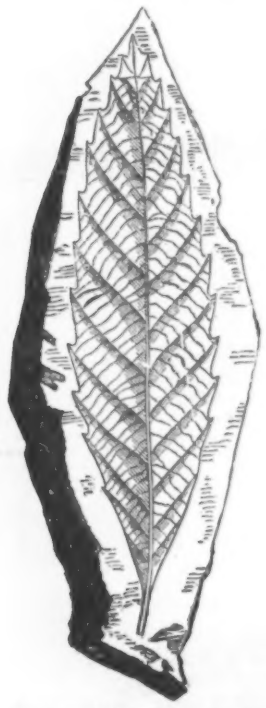


FIG. 1.—QUERCUS PRIMORDIALIS, UPPER CRETACEOUS BEDS, DAKOTA (after Lesquereux).

deposits that we find vegetation most perfectly and abundantly fossilized. On the other hand, every geological formation abounds more or less in animal remains, chiefly those of marine species which lived in the seas along whose floors the rocks were originally laid down in the sedimentary state. In estuarine and lacustrine strata we meet with the largest number of remains of land animals. Their carcasses have been brought down by streams and rivers. The proportion of land animals thus preserved, both vertebrates and such invertebrate forms as insects, bears a certain proportion to the number of actual terrestrial plants which have also been fossilized.

If therefore the geological record is imperfect as regards fossil animals, most of which were marine, it must necessarily be so as regards plants. As to their bearing on the doctrine of evolution, less than ten years ago some of our best naturalists held that fossil animal remains were neutral. So little dependence could be placed on any inference drawn from their geological distribution, owing to the possibility of their unexpectedly being found in other strata than those to which it was supposed they had been limited, that philosophical naturalists preferred to regard palæontological evidence for the time as *nil*. But year after year has witnessed the discovery of new animal forms in strata of various ages and in different parts of the world; and now the most stubborn opponent of evolution is obliged to acknowledge that the balance of evidence from fossil remains is becoming every day larger in favor of the new philosophy.

Much the same may be said of fossil botany. Thanks to the value of mineralized vegetation when it assumes the shape of coal, the formations bearing it have been better studied and explored than any other, so that the chances of finding new vegetable forms have been greatly increased. We have sometimes to skip formation after formation before we can accept any inference drawn from the occurrence of fossil land plants, and we are often surprised by the contrasts between floras thus separated by extensive epochs. Thus, after the abundant flora of the Coal Measures, we meet with but little until we come to the Upper Cretaceous, Eocene, and Miocene formations. Here and there in the Lias, some parts of the Oolite, and the Lower Cretaceous rocks, we come upon local floras, some of which, as in the case of the Upper Cretaceous floras, had an extensive geographical distribution, so that any inferences drawn from their occurrence are much safer than if we had met with a fossil flora in one locality only. Whereas in the animal remains of the successive formations we can witness group after group of marine organisms making their appearance and becoming extinct, the story of the vegetable life of the globe is interrupted by enormous periods of time. This is due to the fact that the greatest number of the rocks with which geologists are best acquainted were formed in seas far from land, where it was impossible for land vegetation to be carried without destroying its distinguishing characters.

Notwithstanding this "imperfection," however, there are certain broad and unquestionable principles which geologists can depend upon in the succession both of animal and vegetable types. Thus we find that the simplest forms appear in the oldest formations, and the most complex and highly organized in the latest. No investigation appears likely to disprove this most important fact. Again, as regards animals particularly, and, far as can be ascertained, with plants also, the most *generalized* types of organized objects precede the *specialized* forms. If we had as good means of identifying plants from fragments as we have in the case of the higher animals, there can be little doubt we should find the same truth holding equally good in the vegetable kingdom. Modern naturalists have made some important discoveries by the light of embryology—that is, of the probable descent of any species by tracing the successive changes which it may pass through as an embryo. In this way it is found that the embryo of a mammal passes through an enormous number of stages, from those representing single-celled infusorial animalcules upward and onward through others corresponding to fish, amphibian, reptile and bird. These embryonic stages are a kind of condensed evolution, taking place and succeeding each other in a few months instead of in millions of years, and occurring in the life history of one animal instead of an incalculable series. Embryology therefore is regarded as illustrative of palæontological evolution.

But here again animal structures give a greater advantage to the student of their history and relationships than plants. The latter have fewer embryological stages through which we can trace their probable lines of descent. This has been attempted by a few English and German naturalists, and with considerable success, but the subject remains an almost unworked field. The most suggestive probabilities as to the origin of some of the leading orders of flowering plants come from a quite unexpected quarter, namely, their monstrosities or teratology. Thus, we find that frequently the *abnormal* conditions or monstrosities of one order of plants correspond to and assume many of the characters distinctive of another order. In this way it is possible some orders may have arisen through adventitious changes in structure brought about by changes in the physical surroundings, such as climate, moisture, and height above the sea-level.

The correspondence in the mode of succession of animal and vegetable remains, as everywhere revealed by the study of geology, renders it very probable that we have hit upon the true order of appearance on our globe. Such terms as were used by the older geologists, as the "age of fish," the "age of reptiles," and "age of mammals," roughly express this method of succession. And beyond modifications in the hard and fast lines where they made these animals to come in or disappear, nothing has been discovered to interfere with the arrangement. Corresponding to this was the classification of the vegetable kingdom, based on fossil remains, founded by Brongniart many years ago, of the "age of acrogens" (or ferns), "age of gymnosperms" (or conifers), and "age of angiosperms" (true seeding-plants). In both kingdoms, animal and vegetable, there is the strongest evidence—evidence which every new discovery strengthens—that the lower preceded the higher, and the general the special forms.

Brongniart's simple classification of the geological order of succession of the three most prominent of vegetable types upon the earth ought not to lead the student to infer that during the "age of acrogens," or ferns, there were no conifers, or that, when the "age of gymnosperms" prevailed, there existed no true seeding or angiospermous plants. The classification indicates only the prevailing groups of vegetation. These can be again divided, so that we find the order of classification corresponds to that of palæontological succession. Thus up to the conclusion of the Silurian period sea-weeds or *algæ* were the dominant types of vegetation; from the upper Silurian to mid-Carboniferous times ferns and club-mosses (*Lycopodiaceæ*) were most abundant. In the Permian and Triassic periods coniferous trees were in the ascendency; then follow monocotyledonous plants, such as palms and grasses in the Oolite and true flower-bearing plants in the Lower and Upper Cretaceous, with abundance of them in the Eocene, a preponderance of them in the Miocene strata, and so onward to our own time. Even among the true flower-bearing or phanerogamous plants we find that the monocotyledonous preceded the dicotyledonous, while the wind-fertilized (*anemophilous*) groups of dicotyledons appeared before the insect-fertilized (*entomophilous*), certainly as orderly as the Acrogens came before the Gymnosperms. For the occurrence of a few insect-fertilized plants among the first dicotyledonous flora no more invalidates this conclusion than does the fact that we find coniferous trees in the Devonian rocks interfere with their existing in the so-called "age of acrogens."

It has been recently shown that the colors of petaled or perianthed flowers exist in the first place because they are useful to plants in attracting insects, and that the visits of insects thus secured cause pollen to be carried from one plant to another, and so produce that degree of crossing which is beneficial. It has been found that the size and color of the corollas of flowers (as in the geraniums), the intensity of their perfumes, or the (more practical) larger amount of honey which may be secreted in their nectaries, are always proportioned to the needs of the flowers to be crossed by pollen other than their own. So necessary is this crossing in some instances that the pistil of a flower is as barren when dusted with pollen from its own stamens as if it had been fertilized with pollen from an altogether different species. It had long been acknowledged in a general way that flowers were necessary to insects, but it is only within the last few years that it has been discovered that insects are quite as necessary to flowers. With the exception of accidental crossing, which may result from such fringe-winged insects as the minute little *Thrips* to be seen in most English flowers, the insects which can fertilize or cross different flowers, so as to make their visits important and serviceable, are limited to two or three orders. Of the orders of insects now recognized by zoologists, one may be regarded as specially adapted to flowers. This is the order Lepidoptera, a peculiarly flower-haunting group all over the world, both in the day-flying species called butterflies and the night-flying species known as moths. Their mouths are in the shape of a trunk or proboscis, which does not allow them to suck food except in a fluid state, such as that in which we find the natural honey of plants. To this universal fact of the Lepidoptera being purely suctorial there is only one exception, in the case of the curious moths in Australia (*Ophideres*), which have boring or terebrant mouths, thus linking the Lepidoptera with other orders of insects. Next to the Lepidoptera in importance to flowers as an order are the Hymenoptera, of which, however, only the bees are purely flower-frequenters, a good many members of this order being even disadvantageous to flowers. Among them we may instance the numerous species of ants, whose fondness for the honey secreted by flowers induces them to climb the stems of plants for the purpose of obtaining it. But as these insects are *wingless* (except a particular set at a certain time of the year, when flowers have nearly all bloomed), and as their bodies are glossy and bare of the hairy covering which in butterflies, moths and bees enables the pollen to stick to the body, it follows that ants cannot be serviceable to flowers in crossing them, while if they steal the honey offered as a reward to serviceable insects, they are so far actually enemies. It is to protect flowers against such predatory excursions as those made by vigilant ants that their stems are covered with hairs and prickles, or gummy with viscid secretions. Some of the Coleoptera or beetles, such as the rose-chafers, and various small species, are of advantage to flowers by carrying away the pollen which attaches itself to the under side of their bodies during their slow and sleepy foraging in the bosom of flowers. A few Diptera also may be useful to plants in crossing them. But enough has been said to prove that the Lepidoptera first, and such specialized forms as the bees among the Hymenoptera second, are the members of the insect world on which flowers most depend for being effectually crossed.

Now, if among all the vegetable productions of the globe those plants which bear conspicuous and attractive flowers are the latest to appear (as we have seen they are, the *anemophilous* group preceding the *entomophilous*), then, as the *Lepidoptera* are so absolutely necessary to the perfect crossing of plants, they ought to make their appearance about the same time. That is to say, if true flowers are the latest of all the developments of the vegetable world, butterflies and moths ought to be the latest evolved among the insect tribes. Remains of insects have been found fossilized in deposits as ancient as those of the Devonian period, and from that time onward to our own, under conditions which would have equally admitted the preservation of Lepidoptera had those insects been then in existence. It must not be imagined that, in spite of their gay colors and attractive appearance, we regard butterflies and moths as the most highly organized types of insects. On the contrary, bees, ants and wasps among the Hymenoptera, and termites, or white ants, among the Neuroptera, by their subtle display of instinct, their knowledge of the division of labor, and the general mode in which they conduct the affairs of the hives or republics

FIG. 2.—BETULA BEATRICIANA, UPPER CRETACEOUS BEDS, DAKOTA (after Lesquereux).

in which most of them live, recommend themselves to our notice as cerebrally the highest endowed of all forms of insect life. But the Neuroptera and Hymenoptera were in existence ages before the appearance of moths and butterflies, although it is not until the Tertiary period that we find them fossilized in such specific forms (termites and ants) as lead us to believe their marvelous instincts had even then been established.

We have seen how it is possible to trace in few words the general order of succession of the leading types of animals, and also of plants. Sir John Lubbock and other philosophical entomologists believe that the various orders of insects came into existence, at different periods, somewhat as follows:—*Orthoptera* and *Neuroptera* in the Devonian epoch; *Coleoptera* during the Carboniferous; *Hymenoptera*, *Hemiptera* and *Diptera* during the Oolitic and Cretaceous periods; and *Lepidoptera* not until Tertiary times set in. The remains of a supposed fossil butterfly have been found in the English Oolites, and named by Mr. Butler *Palæontina oolitica*; but the lepidopterous character of the single wing thus named is doubted by Mr. S. Scudder in his work on fossil butterflies. Two other supposed secondary butterflies have been criticised by the latter author, one of which specimens he has personally examined and declared to belong to another order; and the other, which he has not seen, he does not think is lepidopterous. This examination leaves Lubbock's generalization true, for the present, that the Lepidoptera only appear in Tertiary strata. We see no reason, however, why they should not have appeared earlier, say at the beginning of the Cretaceous epoch, when true flower-bearing plants first made their appearance, although the first flowers may have blossomed more for Hymenoptera than Lepidoptera; and, indeed, the fact that the first flowers were polypetalous rather than gamopetalous—that is, had corollas made up of separate petals, rather than of the petals all joined together as we find them in the common blue bell (*Campanula*)—is an indication that gamopetalous flowers could only be formed when there were insects with proboscides long enough to be thrust down to the nectaries at their bases, as we find them in butterflies and moths.

Thus we see there is a broad parallelism between the ap-

pearance of the more differentiated types of the vegetable kingdom and the development or appearance of various orders of insects. Instead of the appearance of a new order, the differentiation may have been accompanied by such specialization of a large group as the bees among Hymenoptera. Mr. H. Goss has published three very important papers on the insect fauna of the primary, secondary and tertiary periods, in which he has given the proportion of species. Of these we observe the Coleoptera or beetles are best represented. It is one of the most extensive in its geographical distribution—a fact which always indicates the antiquity of organic forms, as it proves they were spread before those physical geographical changes occurred which give the surface of the earth its present features. Among the beetles, also, we find a very extended differentiation; their genera are adapted to almost every habit of life, aquatic, subterranean and terrestrial. They are aborted as well as developed, as in the case of the glow-worm. They live on carrion, fungi, pollen, nectar, wood, leaves and other

In the Stonesfield Slate of England various fossil insects have been discovered. They are represented by large species of *Neuroptera*, such as dragon-flies, and various well differentiated genera of *Coleoptera*, already adapted to different kinds of food and habits of life; but none of them are flower-frequenters. It was in this bed that the supposed fossil butterfly called *Palæontina oolitica* was met with. If this be a true butterfly there must have existed flowers at the time when the Stonesfield Slate was formed, according to the theory that flowers and Lepidoptera go together. The Purbeck beds were formed in a large lake, and under conditions such as are favorable to the preservation of insects; and accordingly large numbers have been obtained from this interesting formation. The orders *Diptera*, *Orthoptera*, *Neuroptera*, and *Hymenoptera* are abundantly represented by fossil gnats, cockroaches, dragon-flies, and huge ants allied to exotic genera. Out of sixty-four species described, the beetles number eighteen. The hemipterous insects follow next, with fourteen species; the *Diptera* with thirteen, and

ful *Cyperites*. The *Antholithes* of the Coal Measures, once believed to be a grass, is now known to be merely a fruit-bearing spike of some coniferous plant. During the "age of conifers" a large differentiation took place in this order. There were coniferous trees living during the Carboniferous period which bore adiantum-like leaves, similar to those still produced by the peculiar conifer from Japan known as *Salisburia*, and "stone fruit," almost like plums, or rather resembling the fruit of the yew, which has long been familiar to geologists under the name of *Trigonocarpum*. These fruits are found in such abundance in some sandstone beds of the Upper Coal Measures as to make them appear almost composed of nothing else. Pines with the ordinary needle-shaped leaves and cone-bearing have always been abundant. The fossil plant known as *Pothocites*, found in the Scottish Coal Measures, and supposed by Carruthers to be the spike of an aroideous species, is imperfect, and some botanists deny its phanerogamous character altogether. Only eighteen species of fossil monocotyledonous flowering

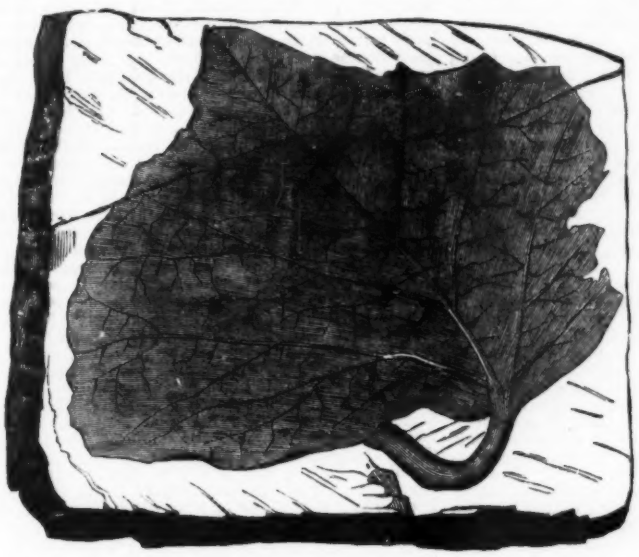


FIG. 3.—POPULUS LATIOR, UPPER MIOCENE, ŒNINGEN.
From a specimen in the Ipswich Museum.

FIG. 4.—ACER TRILOBATUM, UPPER MIOCENE, ŒNINGEN.
From a specimen in the Ipswich Museum.

organic substances, and have their structures modified accordingly. Hence we cannot be surprised that the Coleoptera seem to have been from the first a dominant order, seeing how useful beetles have made themselves in the economy of the globe. Perhaps also the durability of their hard wing-cases (*elytra*) has frequently enabled them to be fossilized when other insects would have been decomposed, and thus caused them to appear numerically more abundant than contemporary orders.

We find the general distribution of insects, in geological time, to be in the order we should expect from what has already been said. The oldest fossil insect is termed by Nicholson *pseudo-neuropterous*—a name which indicates its generalized character. This occurs in the Devonian rocks of North America, but the large size of wing of one of these fossil species (indicating an expanse of five inches) leads us to infer that these Devonian forms cannot be the oldest of winged insects. Mr. Scudder regards this earliest known insect as a "synthetic type"—that is, one which combines peculiarities of structure now distributed and specialized in different groups. In the Carboniferous rocks many species of fossil insects have been met with. Among the Neuroptera we have a member of the *Ephemeridæ* or "May-flies" larger than any now known, having an expanse of seven inches of wing. These are insects which pass the first stages of their existence as aquatic larvæ. The Orthoptera are represented by very generalized forms of cockroaches, crickets, and locusts. Beetles, however, are not yet so abundantly preserved.

In the Secondary rocks large numbers of fossil insects have been found, and here beetles take the leading place. One great storehouse for them is the Lias bed at Schambelen, Switzerland. In England the Rhætic beds have yielded a rich harvest, as may be seen by a reference to the work on "British Fossil Insects," by the Rev. P. B. Brodie. The Purbeck beds are also locally productive of many fossil species. No *Hymenoptera* have been yet found in the Rhætic beds; but 29 species of *Coleoptera*, 12 of *Neuroptera*, 9 *Hemiptera*, and 7 *Orthoptera* from these strata have been described. Two species of beetles have been found fossilized in the Swiss Trias. Prof. Heer has discovered in the Liassic rocks of Schambelen no fewer than one hundred and forty-three species of fossil insects, which are distributed as follows: *Coleoptera* 116 species, *Hemiptera* 12, *Hymenoptera* 1, *Orthoptera* 7, and *Neuroptera* 7. The fossil beetles had even then been specialized into carnivorous types: others were leaf-feeding beetles. Some evidently lived on decaying wood; but as yet there were none which are now known to haunt flowers.

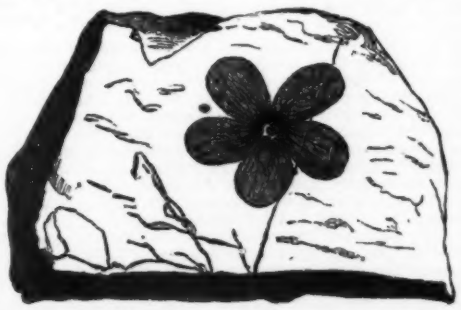


FIG. 5.—FOSSIL FLOWER (*Purana œningensis*), UPPER MIOCENE, ŒNINGEN. From a specimen in Ipswich Museum.

the *Orthoptera* with ten. The beetles are chiefly herbivorous kinds.

When we come to the Tertiary strata undoubted Lepidoptera make their appearance. There is no longer any zoological doubt as to what they are. But this is the period when true flowers began to be abundant, and therefore it is significant we should find specialized flower-loving insects appearing at the same time. As a rich fossil flora, containing true flowers, has been found in formations as old as the Lower Cretaceous in Greenland, it is possible that Lepidoptera appeared before the Eocene period. Nine species of fossil butterflies are found in strata of the latter age at Aix in Provence. The Miocene strata of Switzerland have yielded an immense number of species of fossil insects, which have been described by Professor Heer. In beds of this age at Radoboj, in Croatia, three species of butterflies have been found, one of them singularly allied to an Indian species. In this formation the Hymenoptera are very abundant. From the Swiss Miocene at Œningen Professor Heer has obtained nearly nine hundred species of fossil insects, of which the Coleoptera number no less than five hundred and eighteen. Not only do we find these Miocene beetles differentiated and adapted to all the habits of life which their Oolitic predecessors had already possessed, but for the first time we come across true *flower-haunting* beetles, belonging to groups actually specialized in our own day to particular genera of flowers. So striking is this that Professor Heer infers the existence of such flowers (although they have not as yet been found) during the Miocene epoch. The fossil Hymenoptera of Œningen number *eighty* species, and among these are those highly specialized forms, such as bees, which are always associated with flowers. Three species of butterflies are all which have as yet been recognized. It would seem probable, therefore, that bees appeared before butterflies, and obtained their remarkable specialization by being adapted to the earliest of the flowering plants.

Near the White and Green rivers, bordering on the Territories of Utah and Colorado, an immense Tertiary deposit has been explored by the United States surveyors. Its shales have been found crowded in plates with insect remains, including even the larvæ. One species of *Thrips* has been found whose minute fringed wings, characteristic of its order, are visible under the microscope. Fossil ants occur here, so that their peculiar specialization had already been effected. Only one species of moth, however, has hitherto been met with out of the sixty or seventy fossil insects described.

Later Tertiary beds always contain fossil insects where the conditions are favorable to their preservation; but it would appear as if all the great orders had assumed their modern distinctiveness before the close of the Miocene period. What has since occurred has been chiefly their changed geographical distribution, and the breaking up and differentiating of two of the orders, Hymenoptera and Lepidoptera, so as to adapt many of the species of each to the most abundant or most frequented of the flowers where such insects have been distributed.

We see that a comparison of the order in which insects have appeared leads us to infer the absence of true flowers until the later geological epochs. A parallel development has taken place in insects and flowers during geological times, so as to slowly and mutually adapt each to the other. The order in which the various families of flowering plants have appeared bears a relation to that in which the different groups of insects have succeeded each other. Thus we have first the conifers and cycads, wind-fertilized plants, producing a superabundance of pollen, so that some of it may surely take effect. The grasses and sedges probably appeared during the Triassic, Liassic, and Oolitic periods, although in no very great abundance or variety, or we should have more fossil remains of them than we have in the doubtful plants are recorded as having been discovered in the three formations—Trias, Lias, and Oolite—and some of these are doubtful. This proves how very scanty must have been the flower-bearing flora, for we get no similar poverty of fossil ferns or conifers. The Wealden formation was deposited as a delta at the mouth of a large river—a river watering an enormous area of country, which must have been more or less covered with plants—and the Purbeck beds were formed along the floor of an extensive fresh-water lake. No conditions could have been more favorable for the preservation of land plants than these, yet the number of flowering species is extraordinarily small. Remains of insects, their wings, legs, heads, etc., are preserved, as we have seen; and there is no reason why we should not have found dicotyledonous flowering plants had they been abundant.

In a Greenland formation, which Professor Heer calls *Lower* Cretaceous, plant beds are found which have yielded extraordinary results; 138 species of ferns, 75 of monocotyledonous flowering plants, and one dicotyledonous plant have been described. In the greater part of Europe the Cretaceous period was marked by deep-sea conditions, so that we have little expectation of finding fossil land plants. The *Upper* Cretaceous formation in many places seems to have been

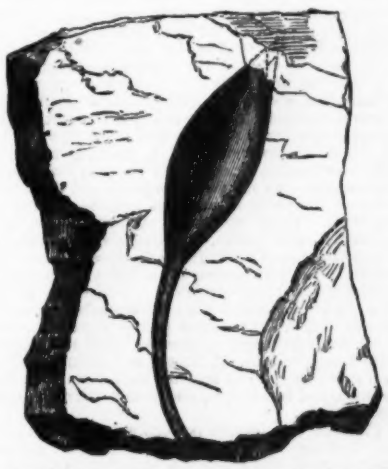


FIG. 6.—FOSSIL FRUIT (*Podogonium Knorrii*), UPPER MIOCENE, ŒNINGEN. From a specimen in Ipswich Museum.

favorably deposited for the preservation of these desirable plants. It should be stated, however, that in the opinion of some geologists some of the so-called "Upper Cretaceous" beds, especially those of Dakota, are regarded as possibly intermediate in age between the Cretaceous and Eocene, so that they form "passage-beds" between the Secondary and Tertiary epochs. The most remarkable strata of these deposits are perhaps those of Dakota, in the Western States of America, whose fossil plants have been figured and described by Professor Lesquereux. Here we find no fewer than one hundred species of dicotyledonous plants. In the Aix-la-Chapelle beds a large number of fossil leaves, etc., have enabled botanists to chronicle the incoming of many orders of plants at an earlier date than had been before imagined. In tropical Africa and Greenland plant-bearing beds of so-called Upper Cretaceous age have also been explored; and

the occurrence of the remains of monocotyledonous and dicotyledonous plants in them proves how widespread and abundant these groups had already become.

All the coniferous and most of the monocotyledonous plants are "wind fertilized" and it is probable that up to the beginning of the Tertiary epoch no such beautiful perianthed monocotyledons as the lilies, tulips, etc., had made their appearance—that, in short, all the monocotyledonous plants were up to that time "wind fertilized." It is curious to note that when the dicotyledons first make their appearance it is also the "wind fertilized" group which comes first. Thus, in the Upper Cretaceous beds of Dakota, out of the one hundred species of dicotyledonous plants described, no fewer than sixty-one are *apetalous*, such as the oaks, maple, etc. (see Figs. 1 and 2). Many of them were catkin bearers as the poplars. Of the remainder, thirty-five species are those possessing *polypetalous* flowers; while only *one* species is *gamopetalous*—that is, has flowers with the petals united into one piece. The proportion of "wind-fertilized" over "insect-fertilized" plants is always greater the further we go back in geological time, thus indicating that the "wind-fertilized" appeared first. If we could get specimens of the entire plants, and were not forced often to depend on leaves alone for the identification of genera, there can be little doubt we should find the earliest dicotyledonous plants to belong to much more generalized types than any now existing. Such is the opinion of Baron von Ettingshausen, who has studied and compared the cretaceous and tertiary floras of the world.

The order of floral occurrence therefore is: 1st, "Wind-fertilized" or *anemophilous* Monocotyledons, such as grasses, sedges, rushes, etc.—gay-flowered or *perianthed* Monocotyledons not appearing for certain until the Miocene period; 2d, Dicotyledons belonging to the "wind-fertilized" division, and bearing inconspicuous flowers or catkins; 3d, Dicotyledons with *true* flowers, but having the flowers composed of several pieces or petals (*polypetalous*); and 4th, Dicotyledons in which the petals are united, so that the flower or corolla is in one piece (*gamopetalous*). Of the *Gamopetalæ*, the *irregular* flowers, such as those of *Labiatæ*, *Scrophulariaceæ*, etc., were developed later still. The showy irregular perianthed flowers, such as Orchids, also appeared among the later floral developments. This is certainly their order of numerical proportion, and we have little doubt it is also that of the actual succession and appearance in time of flowering plants.

The Tertiary epoch is that which up to a few years ago was believed to have first witnessed the introduction of dicotyledonous plants. We have seen that this is not the case. But, as we should expect from the line of argument employed, their number becomes numerically greater as we approach the present era. The Eocene beds of Hampshire and elsewhere have yielded abundant remains of a flora of a nearly tropical character, but which is, on the whole, related to that found in the older so-called "Upper Cretaceous" formations of Aix-la-Chapelle and America. The Eocene plants include many genera now deemed peculiarly Australian, such as the *Proteaceæ;* smilax, dryandras, acacias, azaleas, cactuses, aroids, figs, etc., abounded; and their remains are found fossilized with those of fan-palms, feather-palms, and others. Climbing plants and lianes then festooned the forest trees, as they now do the woods of the West Indies. It is in the Miocene period, however, that we have the remains of the most wonderful flora preserved, especially in the molasse beds of Switzerland. From its warm temperate character, Prof. Heer thinks the climate must then have been about sixteen degrees higher than it is now. One peculiar feature about the Miocene flora is its assemblage of existing genera which have since been rendered locally extinct, so that we now find them in parts of the world at immense distances from each other. This has been greatly the result of subsequent geographical changes, some of which, such as those occurring in the glacial epoch, were of an extraordinarily rigorous character. No fewer than seven hundred species of fossil phanerogamous plants have been obtained from the Swiss Miocene beds alone. Of these nearly three hundred were trees and two hundred and fifty shrubs. One hundred and sixty species were herbaceous flowering plants; many of them grasses and sedges, others with showy blossoms or corollas (Fig. 5). The Miocene flora plainly shows us that a great differentiation had taken place in the form and grouping of insect-fertilized plants since they first appeared. We now meet with *Composite* flowers, where we have an abortion of some and a specialization of other florets, all diminished in size and peculiarly arranged on a disk, so as to suggest the popular idea that the whole colony is only one flower, as is certainly the notion with the daisy, dandelion, sunflower, etc. Such a modification of floral parts would only be expected by a botanist in periods subsequent to the first appearance of these flowers, and he regards them as produced by a gradual modification. *Papilionaceous* flowers, like those of the pea, remarkable for the different sizes and shapes of the petals and their different colors—rarely the same in any two genera—abound in the Miocene beds. There are traces of them in the Eocene, where a nearly allied group, the *Mimoseæ*, resembling them in the construction of their fruits (*legumes*, Fig. 6), are not uncommon. Water-lilies covered the quiet surfaces of Swiss and English lakes during the Miocene period as they do in our own day. Cinnamon trees (now characteristic of the far East) abounded, Proteaceous plants (at present peculiar to the southern hemisphere) grew by their side, magnolias and tulip trees (well-known American forms) sprang up in botanical fellowship. In company with them were almond trees, plum trees, hawthorns, and many others familiar in temperate regions.

The Pliocene and Glacial periods witnessed the local extinction of many of the plants whose more generalized character enabled them to grow together during Miocene times, and the geographical distribution of others to the areas they now occupy. In a great measure the entomophilous flora has been otherwise specialized since then—many plants have become *monœcious* or *dioecious*, dimorphic and trimorphic, cleistogamous or otherwise aborted. These changes are still going on, and the appearance of man has done not a little to add to the disturbing agents in the floral equilibrium of the world. We have seen that the appearance in geological time of the most beautiful of sweetly-perfumed flowers is also that of the insects which now habitually frequent flowers. And as the wind-fertilized precede the insect-fertilized flowers in order of geological time, we contend that the latter may have been modified out of the former. Not unfrequently the same genus of plants contains both insect and wind-fertilized flowers, as in our own common ash (*Fraxinus excelsior*), which is apetalous, and the species naturally abundant in the south of Europe, and now in our ornamental shrubberies, which possesses a corolla, and is therefore insect-fertilized (*F. ornus*). It is not to be concluded that the plants which bear the most beautiful flowers are the most highly organized, any more than such specially attractive insects as the Lepidoptera are also the highest in point of organization and development. Some of the Neuroptera, such as the white ants (*Termites*), and many among the Hymenoptera, as bees and ants, are more cerebrally developed. We have therefore a peculiar aspect of evolution here presented, not necessarily toward *higher* organization, as some people think is imperative in the new philosophy, but in the direction of special adaptation to each other's necessities and well-being on the part of two groups of organisms having no other connection with each other than that of having become mutually adapted to each other's requirements.—*Popular Science Review.*

WHAT IS A DIATOM?

MR. CHARLES STODDER answers this question in the *Science Observer:*

I take my instrument from its case, put on a 1-6 or a 1-10 objective, and on the stage an *Aulacodiscus Oregonus* or a *Coscinodiscus oculis iridis*, and tell them to look. Then follow the exclamations: "How beautiful! how mathematically regular! what exquisite lacework!" Then an effort to see the object on the slide without the microscope. I take the slide off, hold it to the light, and there is nothing visible. Then follows the question, What is it? I give, perhaps, the specific name, but that conveys no idea; then I say it is a diatom. But to most people that also is without meaning (the word not being in Worcester), and the question follows, What is a diatom? That question I propose to answer here very briefly and imperfectly, for a full reply would require volumes, some of the most costly works published being devoted to the diatoms—Ehrenberg's "Micro-Geology," Schmidt's "Atlas" (now being published), to be followed by Prof. Hamilton L. Smith's great work, the work of many years.

Botanists divide all vegetation into two great groups, flowering and flowerless. Diatoms are plants, belonging to the flowerless class, or algæ. They are unicellular, *i. e.*, the whole plant is one single cell; they are all microscopic; only a few of the thousands of named species are visible to the naked eye, and then only as mere specks, but the eye must be armed with the microscope to make out the detail of the structure of the largest, while for the study of the details of the smallest forms the very *highest quality* of instrument must be used, together with a magnifying power—which is an entirely different thing from quality—that was scarcely attemped twenty-five years ago. Probably no scientific study has so much promoted the great improvement in microscopic lenses that has been made in England and America during the last thirty years as the study of these almost invisible organisms. Every advance in the knowledge of their structure or growth has produced the inquiry, Is this all, or is there something yet unseen? This could be answered only by producing lenses of better quality. The diatom cell is filled with the living matter of plants, endochrome and protoplasm, inclosed in a box of silica, secreted and deposited by the cell contents; this siliceous shell is its characteristic distinction from all other vegetable growths. The shells are beautifully sculptured with dots, lines, hexagons, and blank spaces, making them, as seen in the microscope, among the most beautiful objects of nature, always exciting an interest in those who see them for the first time, and in those who have made them the study of years.

They are found living abundantly in both fresh and sea water. Their dead siliceous shells are found under almost every peat bog; they are found fossilized in the Miocene Tertiary strata, in Maryland and Virginia, and in foreign countries; and when free from sand are used for tripoli, or polishing powder. The so-called electro-silicon from Nevada is pure diatom shells. This article will be enough to answer the question, "What are diatoms?" but to learn more the inquirer must first catch his microscope, and then study them in earnest.

OLIVE CULTURE.

AMONG official papers recently printed in New Zealand, under government authority, is a very exhaustive report on the culture of the olive as practiced in Tuscany. This report was written for the purpose of supplying accurate information for the benefit of those wishing to grow the olive in New Zealand, and with the view of establishing what might eventually prove an advantageous industry in that colony. For the purpose of obtaining information for the report, the writer, Mr. John Glyn, of Leghorn, visited the several districts of Tuscany, such as Montojoli, San Romano, the Pianura di Pisa, and the hills in the neighborhood of Leghorn. San Romano is described as being the very center of a large olive-oil making industry. The country around is undulating and very beautiful, the soil appearing mostly of an argillaceous sandy nature of some two meters in depth, resting upon gravel or tufa, and in some cases upon blue Staffordshire clay. The olive trees on these hills have been in their present positions from time immemorial; in fact, it is almost believed by the educated that some of them may have been the actual descendants of those planted by the Phœnicians 600 B. C. The word descendants is used because, although an olive may be utterly damaged above ground either by intense cold, fire, lightning, or other causes, there is so much vitality and tenacity of life in the roots that within a short time it sends up fresh shoots which soon become prolific trees. No one is able to fix a limit to its longevity. Bouche gives it upward of 1,000 years. The trees grow to a very large size when old. There was in Provence some years ago an old olive tree still bearing fruit, although quite hollow, and able to contain as many as twenty persons in its cavity; and even in Tuscany, where every care is given to the culture, the remains of trees are constantly to be seen which have been struck by lightning, yet vigorous and productive, even when in the surviving half a large portion of the center may have been worn away. There is no doubt that the olive is one of the most profitable plants that a farmer or landed proprietor can put into the ground, as, if once planted and carefully attended to in its earlier years, it will become a source of perennial income, living on, as it does, from generation to generation.

The olive is found within a few miles of the sea in nearly all parts of the Mediterranean coasts. Even in Africa it grows in the highlands, but only to a short distance inland. Here the yield of oil is not great, owing to the heat, which frequently dries up the sap, so that the oil is of an inferior quality. The most suitable climate for the tree is a temperate one, such as that of Tuscany, and perhaps Liguria, where its cultivation extends to the tops of the hills, up to a height of from 700 to 1,000 feet above the sea, where the cold is intense in winter and it is not overpoweringly hot in summer. The general opinion is that it thrives best within a short distance of the sea, on hills with rocky or argillaceous gravelly soil. The aspect is of no consequence. Too great heat or drought materially reduces the quantity as well as the quality of the oil, rendering it thick, rank, and greasy; nor is severe cold favorable to good crops. Temperate heat and mild winters are best suited to rapidity of growth and large yields of oil; from this it is considered that the climate of New Zealand, and more particularly that of the Northern Island, is well suited for olive culture. The soil should not be too rich, or else the oil produced is fatty and rank; neither should the trees be planted in a plain, as when the drainage is defective the ground is apt to get sodden, which is injurious to the roots. Hills admit of natural drainage. In some parts of Tuscany, in the plains, where the soil is damp, in order to insure a perfect drainage, which is absolutely necessary, an artificial bed of gravel, stone, or broken rocks, or tufa, is prepared of some depth, and thick layers of rich earth laid above this, so that superfluous moisture may drain off. Provided the plantations admit of an entirely free circulation of air to all parts, and the drainage is perfect, a moist, rainy, or windy climate, if not too cold in winter, is anything but prejudicial to this plant; in fact, the oil is likely to become of a more fluid character in consequence, a great desideratum with Italians. In many parts of this province, as well as in Lucca, the hills, that have but little earth on the rocks of which they are composed, are formed into terraces by walls of loose stones. On these platforms they collect all the earth they can, and successfully plant their olives, which are renowned for the quality of the oil. Even where the soil is poor, they will dig a large hole, fill it with rich manure, and put their trees therein. Winds are considered favorable when coming from the sea; they are supposed to contain saline matter; but the olive does not benefit by being exposed to the sea spray. From this it appears to be the opinion of the generality of these people that proximity to the sea is useful, although it is proved that the plants thrive beyond Florence, some sixty or seventy miles inland. In Tuscany the winters often show as much as from 4° to 8° Reaumur, and in 1709 the cold was so intense as to prove disastrous to the olives, depriving many families of their chief support for several years; in fact, until the trees that had suffered had time to grow and bear again.

The finest oil in the world is produced in the province of Lucca, about twenty miles from Leghorn. The next best quality is Tuscan, then Ligurian, Provence Neapolitan, Sicilian, Spanish, Smyrna, and Tunisian, the last being a thick, strong smelling oil, and used only for soap-making and machinery. From this it will be seen that the temperate climate of Italy is that best adapted to the growth of this tree. The forest oil is of a beautiful straw color, slightly tinged at times with green of extraordinary brightness, very liquid, almost without smell, and of exquisite flavor. It is used by the best families on the Continent for cooking purposes in place of butter, and for salads. The estimated value of the entire yield of oil in Italy is stated at not less than £30,000 sterling.

Regarding the introduction of the olive into New Zealand, and the chances of its success there, Mr. Glyn says that the Italians have informed him that they would carefully cut out the knots or eyes growing out of the trunks of the trees near the base or ground. The best time for this is in the month of October. These they would cover up in earth and moss, then put them into casks filled with sand, which is watered and closed up, and if sent a long voyage by sea it would be beneficial to sprinkle them occasionally, so as to keep them fresh and cool within the tropics. In this way they would bear exclusion from the light for several months. On arrival in the colony they would require to be taken out with care, and put into well-prepared ground, until such time as they had taken root, when they should be dug out with as much surrounding earth as possible, and put into the sites intended for their permanent abodes. These sites, however, should be holes six feet square and four feet deep, filled with a manure of ground bone, horns, hoofs, well-fermented horse-dung, and sheep's or bullocks' blood. They would now require such skilled treatment (as the future well-being of the trees depends entirely on this period of their existence) that the employment of Italians, and more especially those thoroughly conversant with this branch of culture, is recommended. In the pruning of the trees great care is also required; indeed, it is said that it can only be done properly by those whose knowledge has been acquired by years of practice. The trees will begin to bear fruit in five or six years, and the only care they would need would be the cutting of a trench round their bases and dosing them in the spring with liquid manure. They will flourish if treated with potash, soda, lime, silica, or manures containing these salts; feathers and the scrapings of tanneries are often used by the Italians, as these things take long in decaying. They should be placed in rows at from eight to ten feet from each other, at which rate it is estimated that an acre would contain from 400 to 500 trees.

In Italy the olive grounds are not unfrequently manured with the matter from cesspools. These receptacles are the monopoly of the municipality, and are periodically emptied by properly appointed people, who take the stuff into the country, where it is sold to the farmers, who pour it over their fields after plowing. It is more fluid than the London sewage, and is considered of excellent quality, being exclusively house drainage. In Italian olive grounds the fruits are usually gathered in the months of October and November, or even up to Christmas; but by this time they become nearly black. After gathering they are taken to the crushing mills, and the refuse is put into cane bags and subjected to great pressure in a machine. The first process produces the finest quality or virgin oil; the second and third, inferior qualities. The hard kernel, or stone, is crushed for the small quantity of oil it contains, and the pulverized mass, after boiling, is generally used as fuel. Cattle are so fond of the bark and foliage of this tree that it is said to be necessary to fence the fields where it grows. Rabbits are also very destructive to it, but it does not suffer much from injurious insects, more particularly if it is planted in good soils and favorable positions.

It is calculated that the value of a good oil crop in all the countries where the plant is cultivated cannot be less than £100,000,000 sterling annually, and the demand is continually increasing. The French produce large quantities, but not sufficient for their wants, as they took from Leghorn alone in one year 3,300,000 kilos. Owing to their enormous trade in sardines and other articles in oil, their own supply is totally inadequate to the demand. The consumption of oil in Italy is something marvelous. It is used by the people daily, and enters largely into nearly every dish brought to the table, even to their sauces and pastry; and when meat is scarce, or altogether absent, they will put it into their pottage; thus with bread, rice, or paste and tomatoes, chopped herbs and vegetables, they make a savory mess. In Spain, the south of France, in Greece, and in the Levant, it forms one of the

chief articles of diet. In Italy the oil is also used in large quantities by the better classes as an illuminating agent. The Opera House at Florence is lighted solely by moderator lamps, and the light given by the great chandelier, which contains a vast number of these lamps, is inexpressibly soft and agreeable, being brilliant without glare.

In general the Italians do not plant any grain or green crops under the olives. In some parts where the trees stand far asunder they cultivate the vine, but it is admitted that both the olives and grapes suffer in consequence. Italian agriculturists are of opinion that in those countries that have mild winters, and where vines, the fig tree, and the Indian corn thrive and ripen, the olive must necessarily prosper.

Mr. Glyn sums up this notice of olive cultivation as follows: Taking into consideration the great range of country, namely, from the 34th to the 46th degrees of north latitude, where the olive is found, and the infinite variety of climates in which it exists, it has been proved that between the 43d and the 45th parallels of latitude the finest qualities are produced, and that it will flourish and grow vigorously in all this space when not too far away from the sea. Although the quality may be, and doubtless is, materially affected by such causes as climate, position, soil, etc., there is no doubt of its being capable of bearing transplantation to the southern hemisphere. The abortive attempt to introduce it successfully into Australia must be attributed to want of skill and experience in the people employed, and not to any fault of the climate. If necessary, I would guarantee its successful introduction into New Zealand, and am convinced that no country is, in point of climate, better adapted for it than the greater part of the Northern Island, and can recommend it as being one of the most profitable sources of wealth that Providence can confer on a country. Further, I have no hesitation in stating that, with a very moderate outlay, 100,000 plants might be sent out and be put into the ground before the expiration of six months.

GINGER.

THE ginger plant has a reed-like stem, which generally reaches three or four feet in height and is invested with the smooth sheaths of the leaves. The flowers are not produced on the leafy stems, but on short leafless stems, in spikes about the size of a man's thumb, and are of whitish color, the lips streaked with purple. The root-stocks which form the ginger of commerce are from one-quarter to one-half inch thick, knotty, fibrous and fleshy when fresh. The stem dies annually, while the root continues two years. The roots are dug up when about a year old, and in the West Indies usually in January and February, after the stems have withered. They are well washed, freed from dirt, and in some cases, especially with the better kinds, the outer coat of the root is stripped off, and thus arises the division of ginger into white, scraped or uncoated, and into black, unscraped or coated.

The varieties of ginger which enter into commerce are Jamaica, Cochin, Brazil, and Africa. The first three are scraped gingers, the last named is coated. Jamaica ginger is the sort most esteemed, and next to it the Cochin. In the West Indies ginger is propagated by division of the root, the smaller pieces or protuberances being set, each of which throws up two different stems, the leaf stalk and the flower stalk. The land having been well cleared and trenched, the ginger is planted about March or April; it rises to its height and flowers about September, and fades again toward the end of the year. When the stalks are wholly withered the root is thought to be full grown and fit to dry. The larger spreading roots are generally called "hands" or "races," and will occasionally weigh half a pound. In 1874 there were 185 acres under culture with ginger in Jamaica, and the average crop for many years may be taken at 1,000,000 to 1,500,000 pounds. Ginger is a good deal grown in China, and largely used in its fresh state as a condiment and in medicine. Preserved ginger is prepared by securing the roots while they are yet tender and full of sap, and by putting in jars and covering with syrup, which after being changed several times is ready for shipment.

In order to improve the color of ginger, and, according to some authorities, to protect it from the attacks of insects, it is frequently rubbed over with lime; in other cases it is washed in chalk and water, when it is called whitewashed ginger. The surface of ginger is occasionally bleached by means of a solution of chloride of lime, and sometimes even by exposing it to the fumes of burning sulphur. Ginger, especially when ground, is frequently adulterated. Out of twenty-one samples of ginger submitted to careful examination, no less than fifteen were found to be adulterated with such substances as sago meal, tapioca, potato flour, wheat flour, ground rice, Cayenne pepper, mustard and turmeric powder. These foreign substances occur in varying quantities, but in a majority of cases constitute the principal part of the article.—*Boston Cultivator.*

ŒNOLINE, AND ITS PREPARATION.

ŒNOLINE is a new chemical product which appears likely to have important uses in pharmacy and confectionery; and if it should not supersede cochineal in the preparation of medical syrups, it should certainly take the place of arseniferous magenta in red wines. In fact œnoline is the substance to which pure red wine owes its superb color. It appears to have been isolated for the first time in a pure state by Mr. Glenard, in 1858. Quite recently it has been submitted to a careful investigation by Mr. Eugéne Varenne, especially with regard to its production upon a commercial scale.

The process which he recommends is by no means difficult, and appears to us both ingenious and economical. The coloring matter is separated from wine by means of lime; but, instead of acting upon wine, he takes the wine lees, which accumulate in all districts where the vine is cultivated. He stirs lime into these lees so as to form a sort of thin mud of a blackish gray color. This is thrown upon a filter, and washed with water thoroughly, so as to eliminate any alcoholic fluid which it might retain. In order that this filtration may proceed with desirable rapidity, it is well to make use of a suction filter of some kind. The essential point is to let the matter on the filter drain as perfectly as possible; then the mass is taken from the filter and mixed with alcohol at 95°, and just sufficient sulphuric acid is added to neutralize the lime employed. The moment that the acid is added, the œnoline which appeared to be combined with the lime separates from the latter, and dissolves in the alcohol, communicating to it a brilliant and very dark red color. The alcoholic solution is thrown upon a filter, and the spirit passes, carrying in solution the œnoline. In order to separate the œnoline as perfectly as possible from the lime, it is treated with hot alcohol until the last portions filter colorless.

Of course the spirit used in this simple operation is not lost. All the colored solutions are mixed together and distilled by the heat of a water bath. In this way the greater portion of the alcohol employed is collected pure. What remains in the retort still holds all the coloring matter in solution; it is decanted into an evaporating pan, which is then placed in a moderately-heated stove. The solid matter which is left after this evaporation is œnoline. It forms a blackish powder, giving, when crushed upon paper, a crimson streak very similar in appearance to that which is produced by pulverized cochineal in the same circumstance.

It is possible to replace the lime in this operation by subacetate of lead; but there appears to be no advantage in so doing, and it is quite possible that the lead might not be perfectly separated afterward. The product is the same as above, and the yield no greater; therefore lime is to be preferred.

In certain wine districts of France this little chemical product is already a branch of industry not without importance. The œnoline, prepared, as we have just shown, is used to strengthen the color of the finer descriptions of wine. It is of interest to the wine grower to extract this coloring matter from the lees which accumulate upon his works, and which, hitherto, have been of no use to him. Now he colors his finer wines with it, and thereby increases their value in the market. As to the quantity of this beautiful coloring matter which can be extracted by the above process from a given amount of lees, it is not possible to fix it with any certainty, as the lees are more or less rich in œnoline, according to the district, the particular kind of vine, or the season. No doubt we shall hear of this new substance being applied in many other cases.—*Monthly Magazine.*

PLATINUM METALS.

THE perchloride of iron, which results from the refining of gold, contains—besides a certain amount of gold in a very fine state of division, held in suspension—platinum, palladium, chloride of silver, iridium, and rhodium, all in solution. The same liquid also contains a certain quantity of copper, antimony, lead, bismuth, arsenic, tin, selenium, and probably tellurium. When this solution is treated by metallic iron, a pulverulent metallic deposit is obtained, which comprises all the metals we have just enumerated. It is first of all necessary to extract, mechanically, from this deposit, the larger fragments of metallic iron that have found their way into the deposit. Next, the finely-divided iron that is also precipitated with the more valuable metals is dissolved out by digesting the deposit with perchloride of iron. This solution also dissolves a part of the copper precipitated, and, if the digestion is continued too long, it takes up also the palladium. However, this is an inconvenience that can be avoided.

In the next place, the deposit is washed with diluted hydrochloric acid; it is then dried and melted with carbonate of soda and charcoal. The selenium finds its way into the scoria as seleniate of soda. The resulting metallic ingot is granulated in the usual manner, and treated with *aqua regia* containing an excess of hydrochloric acid. Care must be taken that the quantity of *aqua regia* used be insufficient to dissolve the whole of the metallic mass; for it is necessary to dissolve out, firstly, the whole of the copper, otherwise this metal would interfere with the extraction of platinum and palladium. The treatment with *aqua regia* is, therefore, repeated several times with small quantities of acid, to get rid of the copper entirely. The last of these solutions contains a certain quantity of palladium, which is afterward separated by introducing rods of copper, or simply some copper wire, into the solution, which precipitates the palladium in the metallic state.

The metal which remains after these repeated attacks with small quantities of *aqua regia* must be dissolved entirely by the use of a larger quantity of the acid, and the solution must be diluted with water to precipitate the antimony as oxide. It is then concentrated again, and protochloride of iron is added to it to throw down the gold. This, of course, causes the liquid to become charged with perchloride of iron and protochloride of iron, which is very prejudicial to the subsequent separation of the other metals, more especially on account of the production of a certain quantity of protochloride of platinum. Thus, it is far better to precipitate the gold by means of a galvanic current, and to separate the platine immediately afterward in the state of chloroplatinate of ammonium. The latter, on being calcined, leaves spongy platinum containing only 0·5 per 100 of impurities. The mother waters from which the platinum has thus been separated contain an excess of chloride of ammonium, and consequently they are used to precipitate the platinum from other lots of liquid as they are produced. This has for effect to concentrate all the palladium into one liquid, the result of several successive operations. By concentrating this palladiferous liquor, the remainder of the chloroplatinate of ammonium retained in solution crystallizes and can be separated. The last mother water, rich in palladium, is precipitated by the addition of hydrochloric acid followed by a slight excess of ammonia. This treatment brings down the palladium as yellow chloride of palladium and ammonium.

As nothing is said by Mr. Opificius about the metals iridium and rhodium, we must infer that in the German gold refineries they have not been met with in large enough quantity to warrant their separation from the platinum in this process.—*Monthly Magazine.*

CHEMICAL REACTIONS OF THE ELECTRIC EFFLUVE AND UPON PERSULPHURIC ACID.

By M. BERTHELOT.

PERSULPHURIC acid being formed in the reaction of sulphurous acid upon oxygen, it was natural to think that the same compound might be obtained directly by means of anhydrous sulphuric acid, and the supposition has been verified by experiment. Having introduced into an effluve tube 277 milligrms. of anhydrous sulphuric acid contained in a vial tube, the author closed the tube, filled it with dry oxygen (about 60 c.c.), and caused the effluve to act upon it at high tension for eight hours. The bottom of the tube was then heated to disperse certain small opaque masses of anhydrous sulphuric acid not yet attacked, and the effluve was again allowed to act upon it for some hours. At the end of this time the sulphuric acid had disappeared, and in its place was a substance having the aspect of persulphuric acid. The volume of gas which had disappeared was rather more than 20 c.c. at 12°. The product obtained was really persulphuric acid, as it yielded to a standard solution of ferrous sulphate a weight of oxygen equal to 26·2 m.gr. or 9·5 per cent in relation to the sulphuric acid, while theory requires 10·0. The author then examined if any reaction takes place between anhydrous sulphuric acid and dry oxygen, left in contact in a tube otherwise quite similar for ten days without being submitted to the action of the effluve. The result was negative. The persulphuric acid when prepared does not possess an indefinite stability when the action of the effluve is suspended. After some days the fine crystalline needles obtained at first after a few days are resolved into a sort of attenuated snow, which seems to be a combination of sulphuric and persulphuric acids. A similar substance is produced in the outset when the effluve is allowed to act upon anhydrous sulphuric acid in presence of oxygen, and it may hence be regarded as an intermediate product. It appears, therefore, that persulphuric acid as well as ozone and oxygenated water undergoes spontaneously a gradual decomposition when the foreign energy, under whose influence it has taken its rise, ceases to act, that is, to communicate to the matter a special condition and a particular kind of movements or vibrations. The formation of persulphuric acid requires a notable excess of oxygen. If merely the quantities indicated by the equivalents are employed the reaction remains incomplete. This circumstance is explained if we remark that the effluve exerts a double action, both decomposing and combining. In general, binary compounds submitted to the action of the effluve are not simply resolved into their elements, but one portion is decomposed while another portion forms more complex compounds. Thus sulphureted hydrogen yields hydrogen, sulphur, and hydrogen polysulphide. Such phenomena of equilibrium between decomposition, pure and simple, and the formation of complex and condensed compounds are not only met with in the study of reactions brought on by the act of electrization, but they are observed also in reactions induced by the action of heat and of light. The equilibria accompanying such electric, pyrogenic, and photogenic synthesis present one common character: they express the result of two conflicting energies—the chemical energy, which tends to realize among bodies the reactions (combinations, condensations, or sometimes decompositions) capable of liberating the greatest amount of heat, and, on the other hand, the thermic, luminous, or electric energy, which tends to provoke the contrary reactions—those accompanied with absorption of heat.—*Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences.* No. 5, February 4, 1878.

PHOSPHORESCENCE AND FLUORESCENCE.

By M. FAVE.

THE author ascribes phosphorescence and fluorescence to the vibrations of the phosphorescent or fluorescent body propagating in the ether waves of an intensity sufficient to affect the eye, especially when this organ is for the time being withdrawn from the action of the waves which act habitually upon it.

REFRACTION OF GASES AND VAPORS.

By M. MASCART.

The new results obtained by the author are:

	Refraction with Relation to that of Air.
Chlorine	2·63
Bromine	3·85
Hydrochloric acid	1·52
Hydrobromic acid	1·95
Hydriodic acid	3·10
Hydrocyanic acid	1·49
Sulphydric acid	2·12
Ammonia	1·29
Water	0·88
Phosphorus protochloride	5·93
Carbon sulphide	5·05

REPULSION RESULTING FROM RADIATION.

By W. CROOKES.

[Presented to the French Academy by M. Th. du Moncel.]

FOR several years I have been pursuing my researches on the repulsive force resulting from radiation transmitted through rarefied gases. The apparatus I used consisted of a torsion balance, in which the beam for carrying the experimental disks is a straw suspended by a very fine glass fiber. Six disks, each differing from each other, are suspended from one end of this beam, and they are balanced at the other end by a suitable counterpoise. A standard candle, placed at a fixed distance from the balance, supplied the radiation, and the displacements produced by this radiation were increased on a graduated scale by a ray of light reflected from a mirror. A screen was so arranged that the light might fall on any disk selected for experiment without the others being affected. Finally, a standard lampblacked disk was placed in the apparatus in order that the results might be compared. All the apparatus was carefully sealed and attached to a mercury pump capable of carrying the exhaustion to any desired point. My experiments have extended over one hundred different substances, and I have measured the effect produced by them, not only under the influence of simple radiation from a luminous source, but also by removing the invisible heat rays by the interposition of a water-screen. In this manner I found that each substance exercises a more or less distinct action on the absorption of rays. Thus most white powders powerfully absorb the invisible heat rays, while they are almost without action on the luminous rays. On the contrary, the black powders powerfully absorb the luminous rays and only slightly absorb the obscure heat rays, whatever their intensity may be. The different metals present great differences in their action. Iron, for instance, chiefly absorbs the invisible heat rays, while gold is principally acted on by the luminous rays. The substances I have experimented with may be divided into two classes: 1st. Those whose action is increased by the interposition of water-screens with regard to the effect produced on the standard disk; 2d. Those in which the contrary is the case. Among the former may be mentioned copper tungstate, saffranin, precipitated selenium, and copper oxalate; these are more affected by light than by invisible heat. Among class 2 may be mentioned chromic oxide, persulphocyanogen, zinc oxide, barium sulphate, and calcium carbonate: these are acted upon more by the ultra-red rays than by the luminous rays. Remarkable effects may be obtained by combining the substances in these two categories on the disk of the radiometer. Thus, if we alternately coat these disks, which we will suppose to be made of pith, with chromic oxide and precipitated selenium, the radiometer will be seen to turn in one direction when it is exposed to the light of a candle, and the contrary way when a water screen is interposed before the luminous source. A similar radiometer, the vanes of which are coated with saffranin and hydrated

zinc oxide, does not move at all when it is directly exposed to the flame of a candle, but will be set in motion as soon as a water-screen is interposed. In a note which I have had the honor of presenting to the Academy of Sciences, I have shown that when the exhaustion of a radiometer is carried beyond a certain limit its sensibility gradually diminishes until it becomes absolutely null. I have entered more deeply into this question, and have come to the conclusion: 1st. That there is a gradual increase in the sensitiveness of the radiometer until the pressure has attained 50 millionths of an atmosphere (0·038 millim.); 2d. That beyond this limit to 30 millionths of an atmosphere (0·013 millim.) it remains stationary; 3d. Further still, it sinks rapidly until at 1 millionth (0·00076 millim.); 4th. That at 0·2 millionth of an atmosphere (0·00015 millim.) the radiometer refuses to turn even when five candles are put near it. To examine the effects of molecular pressure produced directly by heat upon a radiometer I arranged, besides the system of vanes suspended horizontally, a ring of platinum which could be rendered incandescent by an electric current. The vanes were of transparent mica, and were inclined to each other like the sails of a windmill, and above these vanes was a mica disk, which turned on a separate pivot. The normal direction of this disk was naturally inverse to that of the system of vanes. The following are the results I obtained: (1.) When the apparatus is full of air at the normal pressure of 760 m.m., and the platinum ring was incandescent, the direction of the rotation of the vanes and disk was *positive*, that is to say, that which would be produced by a current of air coming from the platinum ring: this effect must be attributed to the ascending current of hot air. (2.) At a pressure of 80 millims. the disk did not turn. The vanes turned slowly in the positive direction. (3.) At 19 millims. no movement was produced either by the disk or by the vanes. (4.) At 14 millims. the disk remained stationary, but the vanes began to turn gently in the negative direction, that is to say, in a way inverse to their first direction. (5.) At 1 millim. the disk turned in a continuous manner in the positive direction, while the vanes turned rather fast in a negative direction. (6.) At 0·224 millim. the speed of the disk or the vanes was the same, and their rotative movement was the same Below the pressure the speed of the rotation of the vanes diminished gradually, while the speed of the disk increased, and at a pressure of 0·107 millim. the disk turned rapidly in the positive direction, while the vanes were motionless. (7.) With a more perfect exhaustion still, at 0·098 millim. a sudden change was seen. The vanes which had been stationary then began to turn in the positive direction at a speed of 100 revolutions per minute, while the disks turned as before, positively, but with less speed. It is probable that the speed of this disk was diminished in consequence of the rapid movement of the vanes in the opposite direction.* (8.) When the exhaustion was carried beyond 0·098 millim. the speed of the two disks and of the vanes increased till it exceeded 600 revolutions per minute, and it did not seem to diminish with the highest rarefaction, which was at 0·0001 millim. According to the most recent determinations the number of molecules contained in a cubic centimeter of air at the ordinary pressure is probably something like 1,000,000,000,000,000,000,000 (one thousand trillions); consequently, at an exhaustion of 0·0001 millim., 100,000,000,000,000 are still left. This number is sufficiently large to justify the hypothesis that when the molecules are set in vibration by a white-hot platinum wire they are still capable of exercising an enormous mechanical effect.

NEW PRODUCTS OBTAINED FROM COAL-GAS: PONSŒLION, A NEW PIGMENT, AND CYANON, A NEW GUNPOWDER.

By LEWIS THOMPSON.

ALTHOUGH the above substances have been obtained from purified coal-gas, it must not be understood that the author of these discoveries has any more serious belief in the mischievous results said to arise from the sulphur in gas than he has in the witches of Hopkins or the Popish Plot of Dr. Titus Oates; on the contrary, he is not without a hope that by the progress of real knowledge the existing disgraceful enactments regarding coal gas will be sent to keep company with the two comparative illustrations above alluded to, and for the sake of science the sooner this happens the better.

It has been proved that the bisulphuret of carbon, like cyanogen, possesses a power of uniting directly with metals without the intervention of oxygen or any similar body, and hence it has received in that form a distinguishing name, "Erythrogen."

Guided by this property an attempt was made to discover whether erythrogen could displace cyanogen from any of its combinations, and in making this attempt it was not only discovered that cyanogen can be so displaced, but also that, in so doing, two hitherto unknown compounds are produced, both of which possess very remarkable qualities. The first experiment was made upon a sample of coal-gas known to contain a rather large proportion of bisulphuret of carbon, and it was conducted thus:—A set of Liebig bulbs were charged with a solution of caustic potash, in which a quantity of bicyanide of mercury had been previously dissolved, and the coal gas in question was then slowly passed through the bulbs with the following results: in a very few minutes the solution became milky, and this continued to increase for several days, with the deposition of a white precipitate, which, however, by a continuance of the experiment, became first gray, then black, and at last of a beautiful scarlet color, thus proving the existence of at least two, perhaps three, different compounds. It required a great many experiments to discover the nature of these compounds, and also a sure and certain method of making them uncombined with each other; but at length all difficulties were overcome, and the following process adopted:—Having ascertained by analysis that the scarlet compound derived nothing from the coal-gas but the bisulphuret of carbon contained in it, the gas was abandoned, and pure bisulphuret of carbon employed in its stead in this manner. A strong solution of the cyanide of potassium is to be boiled for several minutes upon binoxide of mercury, or, what answers equally well, the nitric oxide of mercury, sold by apothecaries; it is then to be mixed with three times its bulk of a very strong solution of caustic potash, and when it has become cold it must be cautiously decanted into a Florence flask or other convenient vessel, and a considerable quantity of bisulphuret of carbon added to it with frequent agitation. The mixture assumes in rapid succession a variety of tints, passing from white, yellow, brown and gray into black, and if then left to the ordinary temperature of the atmosphere the black is changed into scarlet in the course of twenty-four to forty-eight hours, according to the quantity of caustic potash present; the larger the amount of potash the shorter is the time required for the development of the scarlet color; but this change is very soon brought about by the employment of heat, and therefore the flask containing the mixture should be placed in a water-bath having the temperature of about 110° F., when in about half an hour the scarlet precipitate will have formed in the flask, and we may distill off and collect the surplus bisulphuret of carbon, after which the pigment must be well washed with hot water and carefully dried. As thus obtained, ponsœlion is a scarlet powder of a very brilliant tint, which differs from that of vermilion so slightly that the two substances are very liable to be confounded with each other, but may easily be distinguished by subliming a little of the powder in a small glass tube, when vermilion will retain its red color, but ponsœlion sublimes and forms a jet-black mass, frequently containing numerous metallic spangles that strongly resemble metallic antimony and tellurium, although it becomes red when finely powdered. The tint of ponsœlion is, however, not so purple as that of vermilion, and a very eminent portrait painter has pronounced it "the nearest approach to the natural hue of the European countenance" that he has ever met with. We may therefore conclude that it will come into general use as a pigment, and hence its qualities become an interesting subject of inquiry, and it is satisfactory to find that ponsœlion rivals gold itself in respect to resisting the effect of atmosphere influences, for it is unacted on by any one of the concentrated acids, even when boiling hot, and it is only attacked, like gold, by *aqua regia* and those fluids which generate chlorine; it is, moreover, unaffected by sulphureted hydrogen, or any of the hydrosulphurets, and as a paint may fairly be said to be imperishable. Its composition appears to be very peculiar, though a sufficient number of analyses has not yet been made to settle that question beyond the range of doubt. Nevertheless, it seems to consist of one atom of mercury (202), three atoms of sulphur (48), one atom of carbon (6), and one atom of hydrogen (1), thus making 257 as its atomic equivalent, and leading us to conclude that it is a hydro-erythride of the protosulphuret of mercury, from whence we may infer that it might be made by a very different process to that above described, and indeed we may naturally expect many improvements in the mode of its production.

For example, if we regard ponsœlion as a hydro-erythride of the protosulphuret of mercury, we might expect to form it by merely precipitating a mixed solution of the erythride and sulphuret of potassium by a solution of the protonitrate of mercury; but this experiment has not yet been tried, although if successful it would be a very economical mode of making the pigment.

We have seen that the first effect produced by passing coal-gas through an alkaline solution of the bicyanide of mercury is to create a white precipitate, and if we arrest the process at that point we obtain, in the usual way of washing and drying, a gray-white powder, which, on the application of heat, explodes with much violence, and requires therefore to be examined with care. It has not yet been analyzed, and in all probability consists of two distinct substances, one containing sulphur and the other cyanogen united to some form of hydrocarbon; it is to this last that the name "cyanon" has been provisionally given. As procured in the way described, cyanon is a white powder having a greenish gray tint, and when a few grains of it are heated in a test-tube, it explodes at a heat of about 400° F. with much force and the production of a considerable quantity of soot or carbon, while the mercury is thrown out of the tube to a considerable distance, so that cyanon may truly be said to combine the qualities of both gunpowder and shot. The cyanogen compound, which in cyanon is united to mercury, has been transferred to copper with the production of a copper salt having an explosive quality quite equal to the mercurial compound, and in all likelihood this copper salt is the substance which has frequently caused explosions during the repairing of old gas-meters by soldering them. This explosive quality is, however, destroyed by the action of hydrosulphate of ammonia, and no doubt common gas-liquor would answer the same end, so that it would be a wise precaution to bathe old gas-meters in gas-liquor before attempting to apply a heated soldering iron to them.

To obtain cyanon it is not necessary that there should be an excess of caustic alkali present in the liquor, for this is needed only to insure the formation of ponsœlion; consequently we have merely to boil a solution of the cyanide of potassium upon an excess of peroxide of mercury, and, after filtering the cold liquor, pass a current of purified coal-gas through it until a sufficient quantity of white precipitate has been formed, which must then be washed and dried in the usual way.

During the above process, as well as in that by which ponsœlion is produced, there are formed acids of an unknown kind, part of which remain in the liquor combined with the potash, and it was my intention to carry out the investigation of these things to their complete elucidation, but a domestic calamity has so shaken my health that this is now impossible, and therefore I leave the subject unfinished.

A few words, perhaps, require to be said in explanation of the term "ponsœlion." It is derived from the ancient Roman name of Newcastle-upon-Tyne, which was Pons Ælii, and as the substance itself was first obtained out of gas made from Newcastle coals, the name can scarcely be objected to as a mere mark of distinction from vermilion, for which purpose alone it is intended.—*Chemical News.*

* I have already explained, in a note laid before the Academy last year, that the friction of the air at an exhaustion of 0·006 millim. is only a little less than that which it shows at a normal pressure of 760 millims., and consequently the vanes, having a speed of 100 revolutions per minute, must exercise a considerable reaction on the contrary rotation of the disks.

ON SOME THALLIUM PIGMENTS.

By THOMAS W. SALTER, F.C.S.

AT the International Exhibition of 1871 there was shown a series of thallium colors, made specially by the writer for Messrs. Winsor & Newton, of Rathbone place. Of these colors, the *Chemical News* observed:—"Messrs. Winsor & Newton contribute a series of pigments, of extraordinary beauty, prepared from thallium. The specimens include several shades of yellow and orange-red prepared from thallium chromates by the wet way; and green colors, also constituted of thallium and chromium, with a dark brown, a sulphide of thallium."

Previous to the opening of the Exhibition the following short account of the colors was sent by the writer, on behalf of Messrs. Winsor & Newton, to Professor Abel, F.R.S., Her Majesty's Commissioners' Reporter on Scientific Inventions in relation to Chemistry:—"The range of thallium colors exhibited comprises several shades of yellow, orange, red, brown and green. The yellow, orange and red colors are either chromates, bichromates or terchromates. These were obtained by wet processes, both hot and cold, various precipitants and proportions being employed. Of the two brown colors, the orange-brown, or subdued orange, was prepared by the action of continued heat on the orange bichromate: the other is a sulphide of thallium. The two green colors include a brilliant yellow-green and a rich olive-green. The former was obtained by partially decomposing the bichromate of thallium with boracic acid, the latter was deposited on adding a mixed solution of a thallium salt and green vitriol to a mixed solution of chromate and red prussiate of potash. By varying the mode of manufacture thallium colors can be produced bright or subdued, pale or deep, and of different degrees of transparency. At present the cost of thallium precludes their coming into use as pigments, but it is of importance to the Fine Arts to note all new metals, etc., with a view to testing their fitness for the palette. For the reason stated, the true value of thallium to artists has yet to be ascertained; meanwhile, we have thought the series described would be of interest, as showing the capabilities of thallium as a source of color.

To the foregoing may be added Professor Abel's official report:—"The discovery of the metal *thallium*, by Mr. Crookes, through the agency of spectrum analysis, in 1861, created considerable interest at the period of the Exhibition in the following year, when it was first shown in the metallic form by Mr. Crookes. This metal was first discovered in a seleniferous deposit obtained from a sulphuric acid manufactory; it was afterward found to be very widely distributed, though only in small quantities, in iron and copper pyrites, and also in sulphides of zinc, and was detected in the sulphur, and the copper and zinc obtained from some of these ores. Its properties have since been fully studied, and possess considerable scientific interest; but although somewhat widely disseminated in the mineral kingdom, thallium has hitherto been only found associated in very small proportions with other metals, and there is, therefore, no present prospect of its receiving any useful application. Messrs. Winsor & Newton have indicated one direction in which the metal, if sufficiently abundant, might be turned to good account, by exhibiting a series of "pigments prepared from thallium." These specimens include several shades of yellow and orange-red, which are thallium chromates, prepared by wet processes, with variations of the nature and proportions of the precipitants employed. There are also some green colors, of which thallium and chromium are constituents, and a dark brown pigment, which is a sulphide of the metal. The value to artists of these and other varieties of pigments which can be furnished by the metal has still to be ascertained."

In his edition of "Field's Chromatography, or Treatise on Colors and Pigments as used by Artists," the writer remarked on thallium colors thus:

Thallium Yellow.—The new metal, thallium, yields, in combination with chromic acid, two yellow colors, a pale and an orange. They are not absolutely insoluble in water, and, the sulphide of thallium being brown, would probably be damaged by impure air. But whatever their properties as pigments may be, their habitudes as such are not yet known. The present scarcity of the metal renders the colors produced from it mere scientific curiosities.

Thallium Red.—The orange-yellow precipitate, formed by mixing a neutral salt of protoxide of thallium with bichromate of potash, is converted by nitric acid into an orange-red. The latter compound, which is a terchromate, is almost insoluble in cold water, 2,814 parts being required to dissolve it. If the color be boiled in a large excess of moderately strong nitric acid, it is dissolved, yielding magnificent cinnabar red crystal on the solution cooling. These crystals, likewise, seem to be the terchromate.

Thallium Orange is produced when bichromate of potash is added to a neutral salt of protoxide of thallium, as an orange-yellow precipitate. The scarcity of the metal precludes their present introduction as pigments, but if the chromates of thallium were found to resist the action of light and air, and not to become green by deoxidation of the chromic acid, they might possibly prove fitted for the palette. It is a question whether their very slight solubility in water would be a fatal objection; and, although they would be liable to suffer from a foul atmosphere, we are inclined to think the effects would not be so lasting as in the chromates of lead. Like lead sulphide, the sulphide of thallium ranges from brown to brownish-black, or gray-black; and like it, too, is subject to oxidation and consequent conversion into colorless sulphate. It is, however, much more readily oxidized than sulphide of lead; and hence the thallium chromates would doubtless soon regain their former hue on exposure to a strong light. Mr. Crookes, who discovered this new metal in 1861, believes that the deep orange shade observable in some specimens of sulphide of cadmium is due to the presence of thallium He has frequently found it, he says, in the dark-colored varieties, and considers the variations of color in cadmium sulphide to be owing to traces of thallium. That thallium affects the color is most probable, but it is not necessarily the cause of the orange hue. The tint of cadmium sulphide is a mere matter of manufacture, seeing that from the same sample of metal there can be obtained lemon-yellow, pale yellow, deep yellow, orange-yellow and orange-red. With deference to the opinion of a chemist so distinguished, we hold that thallium rather impairs the beauty of cadmium sulphide than imparts to it an orange shade, the thallium being likewise in the form of sulphide, and therefore more or less black. On chromate of cadmium, made with bichromate of potash, thallium would naturally confer an orange hue.

So far as we know, these observations comprise all or nearly all that has yet been written regarding thallium when viewed solely as a source of material color or pigment. It is proposed to supplement them with some account of the mode of manufacture of the Exhibition colors at first referred to, as well as with some remarks on their value as pigments.

1. *Lemon Yellow* was prepared by adding a very dilute cold solution of ammoniacal chromate of potash to a very dilute cold solution of nitrate of thallium, the resulting precipitate being rendered still paler by subsequent admixture with alumina. The color was washed with cold water by decantation, collected on a filter, and carefully dried on a white porous tile exposed to a warm atmosphere. This mode of washing and drying was adopted in al. cases. As regards the strength of the thallium solution, from 4 to 6 ozs. of the salt were dissolved in 2 quarts of boiling water, the solutions when cold being further diluted if necessary. In one instance where 8 ozs. were so dissolved the solution deposited crystals on standing a night.

2. *Pale Yellow.*—Here a hot solution of chromate of potash was added to a cold solution of the thallium. It was found that, by adding dilute ammonia to the moist washed precipitate, the pale yellow assumed a lemon tint. When dried, the yellow was not thus changed by the addition of ammonia. This pale variety fell more quickly than the deeper yellow and orange sorts, and formed a less bulky precipitate.

In the moist state it was convertible into deep yellow or orange by the action of more or less bichromate of potash or very dilute nitric acid.

3. *Middle Yellow* was produced by carefully and gradually adding very dilute ammonia to the orange obtained in 5, until the desired tint was arrived at. A more direct way of preparing the color is to precipitate the thallium solution with a proper mixture of bichromate and chromate of potash. In the first method chromate of potash may be used instead of ammonia.

4. *Deep Yellow* resulted on precipitating the thallium nitrate with a mixed solution of 2 parts chromate and 1 part bichromate of potash.

5. *Orange Yellow.*—Formed by adding a mixed solution of equal parts chromate and bichromate of potash.

6. *Orange Red.*—Made by mixing hot solutions of thallium nitrate and bichromate of potash. The orange precipitates are more bulky than the deep yellow, just as the deep yellow are more bulky than the pale and lemon. Moreover, they are less easily washed, taking a longer time to settle, and yield more highly-colored washings.

7. *Red.*—A boiling mixture of equal parts strong nitric acid and water was added to the washed orange-red precipitate, and the solution suffered to remain a night. The crystalline deposit was then washed with cold water and dried without heat. Unless a large quantity of acid be employed the orange color is but partly dissolved, and the hot liquid requires decantation before being set aside. An inferior red was produced by boiling the orange-yellow, with constant stirring, in a mixture of 75 parts strong acid and 10 parts water.

8. *Orange Brown or Subdued Orange.*—By carefully heating the finely-ground orange-red powder over sand the color assumed a brown or subdued-orange shade. On so heating a mixture of equal parts of orange-red and pale yellow, a brownish or subdued yellow was obtained. When the orange-red was ignited for some time in a porcelain crucible the powder fused and liquefied, becoming solid on cooling, and turning out of the crucible in the form of a highly-polished mahogany cone, very weighty and very hard. This yielded on grinding a rich orange-brown powder of a gritty texture.

9. *Green.*—The yellow chromate of thallium was intimately mixed with three times its weight of boracic acid and carefully ignited in a clay crucible. A small quantity of boiling water was added to the green mass thus formed, the color being afterward washed with cold. By varying the proportions, either a yellow, yellowish-green, or blue-green may be produced, according as the chromate is more or less decomposed.

10. *Olive Green.*—A mixed solution of thallium nitrate, with half its weight of green vitriol, was added to a mixed solution of chromate of potash, with half its weight of red prussiate.

11. *Brown.*—This was precipitated from a cold solution of thallium by somewhat dilute sulphide of ammonium. Another brown is formed when a mixed solution of caustic potash and red prussiate is added to the thallium nitrate.

Without going into minute detail, such is a brief description of the processes employed in the manufacture of the twelve preceding colors or pigments, some of which, it was afterward found, were merely colors, and not fitted for pigments. A pigment is necessarily a color, but a color is not of necessity a pigment. To be a good pigment a color must possess certain physical, chemical, and artistic advantages; but, to be a pigment at all, a color must needs be physically qualified. Wanting in this respect, the following colors must be expunged from our list of thallium pigments: The red, by reason of its too crystalline nature, and the green, olive green, and orange brown obtained by ignition, owing to a tendency of the yellow contained in them to separate and float on the surface.

As a rule, the stability of a color is more severely tried in water than in oil and on this account the former was selected as the trial medium. It may be remembered that, the sulphide being more or less brown or black, the writer conjectured that the chromates "would be liable to suffer from a foul atmosphere." Strange to say, experiment proved this conclusion to be wrong, showing—not for the first time—how liable are theory and practice to clash in the case of colors. A range of water-rubs of thallium chromates and a water-rub of white lead were shut up in a room filled with sulphureted hydrogen gas, with the result that, while the lead was completely blackened, the color of the chromates was quite unchanged. As regards exposure to light and air, the *Lemon Yellow* altogether lost its brilliant purity of hue, assuming a blackish-green shade; the *Pale Yellow* similarly suffered to a less extent; the *Middle Yellow* lost its beauty in a still less degree; the *Deep Yellow* became somewhat dull; the *Orange Yellow*, *Orange Red*, and *Orange Brown* were scarcely altered; the *Green* changed from a yellow-green to a blue-green; the *Olive Green* blackened in hue; while the *Brown* became whitish and chalky in the dark portion of the rub, partly disappearing in the middle and wholly vanishing in the tin wash.

Pure, brilliant, of good body, working well, and entering kindly into admixture, the deep yellow and orange chromates of thallium might fairly lay claim to a place on the palette but for the presence there of superior and far cheaper pigments of the same class of color. With the deep yellow and orange cadmium sulphides at hand, however, the introduction of thallium chromates would be superfluous, even if their excessive costliness were not a bar to commercial success.—*Chemical News.*

THE TRANSIT OF MERCURY ON MAY 6TH.*

You will have noticed, some months since, that the French Government had decided to send an astronomical party to California to observe the transit of Mercury on the 6th of May; and more recent inquiries have been made to me by the Superintendent of the U. S. Naval Observatory with regard to the proper locations for making the necessary observations. But preceding these announcements, and, in fact, over two years ago, I had proposed to the Superintendent of the Coast Survey to observe the transit upon this coast, which is so favorably situated for witnessing all the phenomenon. Unfortunately, there are not funds available for the purpose, and the largest available telescope on the Pacific side of the continent is yet unmounted, for the same reason. You will also recollect that in 1876 Le Verrier asked the co-operation of astronomers in making search for the problematical planet Vulcan; and a subsequent discussion of some of the supposed transits of this body led to a more positive conclusion of its existence, and a second call from Le Verrier and from Airy for renewed search, especially upon this coast; because should the phenomenon take place late in the afternoon in San Francisco, it would of course be invisible to the observatories in the Atlantic or Western States.

From a profound discussion of the inner group of planets, Mercury, Venus, the Earth, and Mars, Le Verrier reached the conclusion that the motion of the perihelion of Mercury is much greater than what is due to the action of the known planets. His comparison of the transits of Mercury observed before 1848, with the motion of the planet as determined from the theory of gravitation, had indicated that the perihelion of Mercury moves 40 seconds of arc more rapidly in a century than it should do from the gravitation of all the known planets of the system. He accounted for this motion by supposing that a small planet, or a group of small planets, revolved around the sun within the orbit of Mercury. The observations discussed by Le Verrier do not exhibit any motion of the node beyond that due to the action of the known planets; and, as a consequence, this necessitates the supposition of an intra-mercurial planet, or a group of planetoids nearly in the plane of the orbit of Mercury. Newcomb says that to produce the observed effect upon Mercury their total mass must be three or four times that of Mercury. Being very small individually, but of such great mass in the aggregate, their number must be counted by thousands or by millions; and, in fact, may only exist as a cloud-like mass. He suggests that in zodiacal light there exists such a diffused mass; and the question suggests itself whether the matter which reflects this light can be that which causes the before-mentioned effect upon Mercury.

I have, in a former paper discussing the periodicity of the sun spots, been led to consider that the effect of all the planets upon the molten matter of the sun will be to deform the figure of that body in an almost infinitesimal degree and yet sufficient for the constantly changed form to react in an appreciable manner upon the nearest planets. If this is the case, we have here another source of disturbance of Mercury's motion.

The accurate observation of the present transit of Mercury is of especial importance, because it may afford data that will be decisive of Le Verrier's deduction of the yet unaccounted-for motion of Mercury in perihelion.

The U. S. Naval Observatory has therefore issued a pamphlet of instructions to observers, and asks that every effort be made to have the phenomenon observed by all who have the requisite instrumental equipment.

The outfit is enumerated as follows:

1. A telescope of not less than three inches aperture, with a magnifying power of not less than 90 diameters. Observations with smaller telescopes or with lower powers will be of value mainly as to what character of results small instruments will yield.

2. A pocket or marine chronometer, or a good clock having a seconds pendulum.

3. A transit instrument or sextant for determining the error of the time-piece. If a sextant is used, the time should be determined by altitudes on both sides of the meridian.

In regard to the size of telescope recommended as the least from which good results can be obtained, I would remark that if a three-inch object glass will give good results at the elevation of San Francisco, a two-inch objective will give equally good results at the height of Summit station, on the Central Pacific Railroad. In my experience at Verde, 5,500 feet elevation, I was able to see the companion of Polaris every night with faint illumination in the telescope of only one and seven-eighths inch objective. With a good three-inch objective I can rarely see it at San Francisco.

In regard to the time-piece and the sextant with artificial horizon, I would remark that many of the finer American machine-made watches are sufficiently good time-pieces for the determination of the epoch of the phenomenon, provided a series of good sextant observations are made in the morning before the observations and during the afternoon, and that in using the sextant for the determination of time all its errors should be carefully examined and determined beforehand, and every item of work or experiment with this or any other instrument very fully recorded. It is very easy to record too little; too much cannot be entered in the note-book. In using the artificial horizon the observer will find that a capital protection to the quicksilver surface from the effects of the wind consists in spreading a frame of lace or mosquito-bar over the artificial horizon, without the usual glass roof. And with this protection a bucket of water will give a very good horizon.

It is necessary that the time should be correct within one or two seconds; a greater error would lead to misinterpretation of the observation or to an erroneous deduction. It is useless to attempt determining the contacts of Mercury with the sun's limb to the fraction of a second, even with higher powers, but the observer should endeavor to make an estimate of his probable error.

It is possible that arrangements can be made to communicate Washington clock time to observers through the Western Union Telegraph lines, but such arrangement has not yet been completed. If I am in the city, I will be ready to transmit San Francisco time to any observer on this coast.

The computed time for the first contact of the limb of the planet with the disk of the sun is on the 6th of May, at 10h. 5m. 35s. A.M., mean time of San Francisco, and the contact will probably occur within a minute, or, at the most, within a minute and a half of this time. The observer must therefore determine beforehand, say for several days before, the error of his time-piece, so as to know when to begin to watch for the contact. It is doubtful, however, if any one will see the epoch of actual first contact, but I believe that with a five (5) inch glass, high power and perfectly still atmosphere, the planet will be first detected outside the sun. In that case the observer will be able to determine precisely the time of the first contact. All the appearances of the sun's limb should be carefully noted, whether the border is steady and sharply defined, or whether undulating, blurred, wavy, boiling, etc. These can be described by the observer and written out by the assistant or recorder before the observations actually commence; but the observer should not fatigue his eyes too much before he needs their use for the main object in view.

In a telescope which sees objects in their natural position the planet will make contact with the sun's border at a point about 95° from the vertex round by the left, or 5° below the extreme left-hand edge of the sun. For a telescope that inverts, the contact will take place about 5° above the apparent right-hand edge. The edge of the sun can very readily be determined by placing a vertical spider-thread in the telescope tangent to the edge of the sun.

Should the observer fail to see the instant of first contact, he may note the time when the dark edge of the planet has just entered the disk, and make a drawing to illustrate the conditions exhibited at the time of record. To an inexperienced observer, and even to relieve the experienced observer from counting seconds or half seconds for one or two minutes, I advise that an assistant, with watch in hand, note the time of contact or any other phenomenon upon the call of the observer, adding thereto promptly such explanations as are given.

Those who are earnestly interested in this matter should study the phase of contact painted upon a board and placed at a distance of not less than half a mile. The pamphlet of the Observatory furnishes diagrams for this object, and I hope to have copies to transmit to those intending to observe.

INTERNAL CONTACTS.

Two or three minutes after the first contact the planet will advance its full diameter of 12 seconds of arc upon the sun's disk, and thus afford the second contact, the time of which phenomenon can, under favorable circumstances, be determined with precision, and the observer should be prepared to note it with the utmost care, watching zealously all the attendant phenomena, especially the character of the definition of the limb of the sun and of the planet, because upon this will mainly depend the value of the observation. One of the most important means of ascertaining whether the contact is to be sharp, clear, well defined, and steady, will be the sharpness of the bright cusps of the sun, formed after the planet is more than half its diameter on the sun. If they are sharp pointed, undisturbed, increasing in length and narrowness regularly, the conditions point to a favorable result, and the trained observer can watch closely until these cusps meet. The instant of meeting is the epoch of the contact.

But if the atmosphere is unsteady—such as you see in an exaggerated case when looking over a wheat field on a hot summer's day—the cusps will appear ill-defined, waving, suddenly prolonged and shortened, blurred. The unequally refracted waves of light will produce a confused image, which will lead the observer to doubt when the cusps actually meet; in other words, when the contact takes place. This confusion may mislead him five or more seconds. In the transit of Venus it has exhibited itself much less satisfactorily than this quantity in the English eye-observations. Let the observer bear in mind that so long as he can see a black separation of the cusps contact has certainly not taken place. Toward the instant of the cusps meeting the space between them breaks up in a confusion of minute atmospheric waves that seem not solid black. The moment of true contact is, of course, that at which the first undulation of true sunlight is seen across the dark space as the cusps join. When sunlight appears undulating along the line of contact the contact is past. If the observer hesitates, and notes the phenomenon at this time, he should explicitly state all the circumstances and appearances.

The last contact of the planet with the sun will occur at 5 hours, 39 minutes, and 15 seconds P.M., San Francisco time, but the third contact, or second internal contact, will take place two or three minutes earlier, and both of these are important.

The third contact, or the second internal contact as it is designated, may be observed in the same general manner as the first, but taking care that the instant of the closing out of the sunlight is the epoch of contact. If the observation is delayed until the cusps are separated, the contact is passed, and if the observation is made after the contact all the appearances and a diagram should be added.

The fourth contact or second external contact is more difficult to observe than the internal second or third contacts, and it is doubtful if any but a skilled observer will observe it with precision. If the limbs of the sun and of the planet are very unsteady, boiling, diffuse, or undulating, it will be next to impossible to note the instant when the last segment of the black body of the planet leaves the sun, because the deformed edge of the sun is very slight indeed.

In addition to these observations, I suggest to observers, who have a small transit placed in the meridian for the determination of the clock error, that the transits of the first and second limbs of the sun be observed on the meridian, and that the transit of the planet, as projected on the sun's disk, be also observed—the first and second limbs. This would give one of the two necessary co-ordinates for determining the exact position of the planet; the other would require observations of the difference in altitude, at meridian transit, of the sun's upper or lower limb and the upper or lower limb of the planet; the latter, in fact, both sets, would give measures of the planet's diameter.

PLACE OF OBSERVATION.

There has been mentioned in all these observations the ill-defined edge of the sun and planet, giving rise to what is known as the "black drop," "ligament," etc., apparently connecting the limbs of the two bodies; even in the published report of the Astronomer Royal of England, these apparent conditions are treated as cosmical phenomena, and have always been so treated, but you will recollect that several years since, and especially before the transit of Venus expeditions, I endeavored to prove, and in my own mind was perfectly satisfied, that the phenomena were wholly atmospheric. Now in the pamphlet of the U. S. Observatory and in Newcomb's Practical Astronomy these views are adopted.

This being the fact, I have suggested that the observations be made on the highest available points in this State, say, on the highest accessible peaks of the Sierra Nevada. If these are not accessible, on account of the snows, by the first of May, then I recommend the peak of San Bernardino, 12,000 feet elevation, and almost isolated, so that the atmospheric conditions would be, in my judgment, remarkably advantageous. Upon the means of reaching the summit, I have already had the pleasure of a personal conference with Mr. Wright, of San Bernardino, who has made the ascent. At this elevation, one-third of the atmosphere is below the observer, and the infinitesimal disturbances from irregularity of atmospheric refraction will be much lessened.

Barring this position, I suggest Summit station, on Central Pacific R. R., at an altitude of 7,200 feet; and as the next favorable for ease of ascent, there being a wagon road to the summit, wood, water, and a hotel near the summit, Mt. Diablo, 3,857 feet above the sea.

The observations at great elevations will, I am convinced, dispel the illusion of "black drop" being a cosmical phenomenon; while combined with the observation of the transit at low elevations, they will serve to determine how the ligament and black drop phenomena may be interpreted for the recent transit of Venus work. The arbitrary method adopted by the Astronomer Royal is not at all satisfactory to my mind, although the results lead to a parallax nearly equal to that derived from the other methods.

*Read before the California Academy of Sciences by Prof. George Davidson, U. S. Coast Survey.

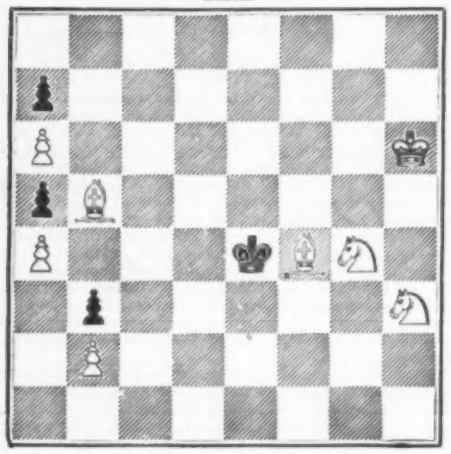
SCIENTIFIC AMERICAN CHESS RECORD.

[All contributions intended for this department may be addressed to SAMUEL LOYD, Elizabeth, N J.]

PROBLEM No. 72. BY GEO. E. CARPENTER.

First Prize Dubuque Tourney, 1870.

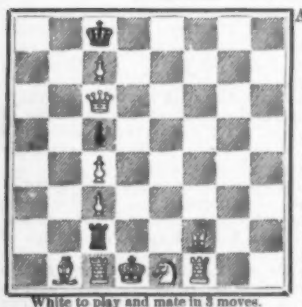
Black.



White.

White to play and mate in four moves.

JOACHIM LOWENTHAL.



White to play and mate in 3 moves.
To the memory of Lowenthal by Dr. MOORE.

LATE as it may seem to give an extended notice of the death of this distinguished player and critic, no more appropriate time could be selected than the present to give his portrait and a short sketch when the eyes of the entire chess world are being drawn toward the tournaments inaugurated through the instrumentality of his liberal bequests. Nothing seemed to us more natural than that one who had devoted his whole life to the cause of chess should have bequeathed his entire fortune toward the perpetuation and advancement of the game he so loved, and it was peculiarly in keeping with the honesty and simplicity of the man to do so.

As a distinguished player, analyst and writer, Mr. Lowenthal has stood prominently before the community for upward of forty years, having taken part in many matches and tournaments, and was the editor of the chess departments of the *Era* and *Land and Water*, as well as a contributor to all of the leading chess magazines His Tournament Book of 1862, as well as other reports connected with the transactions of the British Chess Association, have become standard works, and his compilation of Morphy's games is the only reliable record of the victories of the world's conqueror.

We enjoyed an extended and most intimate acquaintance with Mr. Lowenthal, dating from our first introduction to the world of chess to his untimely death in July, 1876, and have a valuable collection of his letters, which, like his conversation, were ever most charming and free from that venomous, jealous, fault-finding vein that is peculiarly characteristic of the great chess players.

It is true that Mr. Lowenthal played upon even terms and with marked success against the strongest players of the day, but he never was a successful match player, and will never be regarded as one of the recognized champions. The following extract from a letter from Mr. I. O. Howard Taylor is very suggestive of the man as we knew him:

"Lowenthal was slimly built and short, but he struck one at the first glance as an intellectual *gentleman*. He was courteous to a fault, amiable and peace-loving, of a nervous, sensitive temperament; but brain power was scarcely balanced by bodily stamina, and physique alone was wanting to place him in the highest rank of chess.

"He excelled in the openings, and had studied end games profoundly. In the middle game there was absent that even level of skill which is so necessary to success in match play. He was an accomplished rather than a powerful player, and his *parties* exhibited more skill than force.

"An elegant and refined combination would sometimes be succeeded by a blunder as gross; and perhaps no player of such distinguished reputation (Kieseritzky excepted) was less able in a match to do justice to his full talents. A disastrous nervous excitement marred his play and cost him many a game fairly won—but, alas!—not *scored*."

He was of Hungarian birth, but exiled from his country on account of patriotic views, and we find him therefore a sojourner in many lands, a man of much learning and experience and a skillful linguist.

He took part in the famous correspondence match, 1843-5, Pesth *vs.* Paris. He visited this country in 1850, during which time he contested the two memorable games with Paul Morphy, then a lad of thirteen. He removed shortly afterward to London, where he spent the remainder of his busy life, making but short trips to the Continent. We last met him at Paris during the Exhibition of '68, and then took occasion to make a pencil sketch of him.

DUBUQUE PROBLEM TOURNAMENT NO. 1.

THIS interesting Tournament was announced by the indefatigable Prof. Brownson in his Dubuque *Chess Journal*, Dec. 31, 1870. Seven prizes were offered, the novelty of which consisted in the prizes being awarded by the entire body of solvers of the *Journal* instead of by the customary umpire, no competitor to receive more than one prize. The prize for the best problem of the Tournament was awarded to Mr. George E. Carpenter (No. 72).

ENIGMA No. 39.—BY JOHN GARDNER.

Prize for the best two mover.

White.—K on Q 8, Rs Q Kt 2 and 6, B K R 4, Kts Q B 2 and 7, Ps K R 5, K 4, Q B 3 and Q R 4.
Black.—K Q B 4, Bs Q Kt 5 and Q B 3, Ps K R 3, K 4, Q B 5, Q Kt 2, and Q R 4.
White to play and mate in two moves.

ENIGMA No. 40.—BY W. A. SHINKMAN.

Second best two-move problem.

White.—K on K sq, Q Q B 6, B Q 4, Kts Q 3 and Q R 3, Ps Q Kt 4, Q 5 and K 6.
Black.—K Q R 3, Q K R sq, B K B sq, Kts Q B 6 and Q Kt 6, Ps Q R 2, Q Kt 3 and Q B 2.
White to play and mate in two moves.

Prize for best three-mover, G. F. Bixby. (See No. 73.)

ENIGMA No. 41.—BY MAX JUDD.

White.—K on K Kt sq, Bs K Kt 3 and K B 3; Kt K 5, Ps K Kt 2, Q R 3, Q Kt 4, Q 7 and K 6.

Black.—K Q 3, Q Q R sq, R Q Kt 3, B Q R 2, Kts Q B sq and Q 4. Ps K 2, Q B 2 and 5, Q Kt 4 and Q R 5.
White to play and mate in three moves.

ENIGMA No. 42.—BY L. W. DAVIS.

For best four-move problem.

White.—K on Q R sq, R Q R 5, Bs K sq and K Kt 8, Kt Q B 2, P Q 4.
Black.—K K 5, Ps Q 3, K 7 and K B 5.
White to play and mate in four moves.

The seventh prize was not awarded.

JOACHIM LOWENTHAL.

ANDERSSEN VS. PAULSEN.

WE are indebted to the *American Chess Journal* for the following concluding game of the match between Paulsen and Andersen played after the termination of the Leipzig Chess Congress, in which tournament it will be remembered Mr. Paulsen carried off the highest honor, Andersen and Zukertort tieing for second and third positions.

In several previous tournaments Andersen had received the first prize and Paulsen the second; after each encounter, however, Paulsen had reversed the decision by winning in a set match; in this case, however, he confirmed his victory by winning the first prize and then defeating the great German master by a score of five to three and one draw.

[*Ruy Lopez.*]

MR. ANDERSSEN.	MR. PAULSEN.
WHITE.	BLACK.
1. P to K 4	1. P to K 4
2. Kt to K B 3	2. Kt to Q B 3
3. B to Kt 5	3. Kt to K B 3
4. Kt to Q B 3	4. B to B 4

Not quite satisfactory. The following has been suggested as a continuation more favorable to the defense: 4. ——, B to Kt 5; 5. B x Kt, Q P x B; 6. Kt x P, B x Kt; 7. Kt P x B, Kt+ P; 8. Q to K 2, Q to Q 4, etc. Or, 5. K to Q 5, Kt x Kt; 6. P x Kt, Kt to Q 5; 7. Kt x Kt, P x Kt, etc.

5. Castles.	5. Castles.
6. Kt x K P	

Condemned by the German Hand-book, but nevertheless a good move.

	6. Kt x Kt
7. P to Q 4	7. B to Q 3

Most of Mr. Anderssen's subsequent embarrassments spring directly from this. Surely B Kt 5 would be less injurious, viz.: 7. ——, B to Kt 5, 8. P x Kt, B x Kt; 9. P x B, Kt x P; 10. Q to Q 4, Kt to Kt 4; 11. P to K B 4, Kt to K 3, and he can make a good defense.

8. P to K B 4

Much superior to the immediate capture of the knight, which had been tried in some of the previous games in the match and found inefficient.

	8. Kt to Q B 3

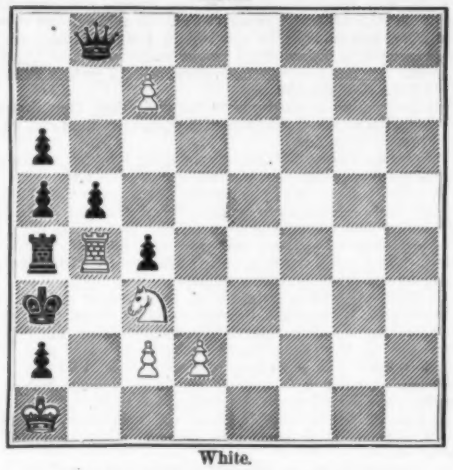
The *Schach Zeitung* remarks: If Kt to Kt 3, 9. P to K 5 would follow, and if B to K 2, then 10. P to B 5 and white has a controlling position.

9. P to K 5	9. B to K 2
10. P to Q 5	10. B to B 4+
11. K to R sq	11. Kt to Q 5

PROBLEM No. 73. BY G. F. BIXBY.

Three-move Prize, Dubuque Tourney, 1870.

Black.



White.

White to play and mate in three moves.

And again: If Kt to Kt sq, then 12. P x Kt, Kt P x P; 13. B x P, R to Kt sq and white will have to withdraw his bishop on account of B to R 3 threatened by black, but he can maintain the pawn with ease.

12. P x Kt	12. Q x P
13. Kt to K 4	13. Q to K 2
14. B to Q 3	14. B to Kt 3

He should have played the queen's pawn at all hazards. The time lost on this move renders a successful defense almost impossible.

15. P to K B 5	15. P to K B 3
16. Kt to Kt 3	16. P to Q B 3

Forced, in order to save his knight.

17. P to Q B 3	17. Kt to Q Kt 4
18. Q to Q Kt 3	18. Kt to Q 3
19. B to K B 4	

Mr. Paulsen might have gained a pawn here, but rightly chose to play for more.

	19. Kt to K B 2
20. P to Q 6	20. Q to Q sq
21. Q R to K sq	21. B to Q R 4
22. B to Q B 4	22. P to Q Kt 4
23. B x Kt	23. R x B
24. R to K 7	24. Q to K B sq

The loss of a piece is inevitable after his next move and the loss of the game a question of time.

25. K R to K sq	25. B to Q R 3
26. Q to Q R 3	26. Q to Q sq
27. P to Q Kt 4	27. P to Q B 4
28. P x P 3	28. Q to Q B sq
29. Q to Q Kt 3	29. P to Q B 5
30. Q to Q sq	30. B to Q Kt 2
31. P to Q R 6	

Should black take this pawn Q to Q 5 finishes him at once.

	31. B to Q B 3
32. Kt to K R 5	32. R x R
33. R x R	33. K to R sq
34. Q to K Kt 4	34. Q to K B sq
35. Q x P+	35. Q x Q
36. R x Q	36. P to Q Kt 5
37. P x P	37. P to Q B 6
38. R to K 7	38. R to K B sq
39. K to Kt sq	39. P to Q B 7
40. R to K 2	40. B to Q R 5
41. R to K sq	41. B to Q Kt 4
42. B to K R 6	42. R to Q B sq
43. Kt x P	43. B to Q 6
44. Kt x Q P	44. B x P
45. Kt to Q B 5	45. Resigns.

SOLUTIONS TO PROBLEMS.

No. 66.—BY A. BAYERSDORFER.

WHITE.	BLACK.
1. R to Kt 5	1. P x B
2. Kt x P	2. K x P
3. Kt to K 4 dis ch	3. K x Kt
4. R to K 5 mate.	
	1. K x P
2. B to K 4 ch	2. K to B 5
3. R to Kt 6	3. B x Kt
4. P x B mate.	
	1. B x Kt
2. R to Kt 6 ch	2. K x P
3. P to K 4 ch	3. B x P
4. B x P mate.	

No. 67.—BY J. BERGER.

WHITE.	BLACK.
1. Q to B 4	1. K x R
2. Kt x K B P	2. K to K 3
3. Q to K 5 ch	3. K x Kt
4. Q to K 8 mate.	
	1. K to K 2
2. Kt to Kt 6 ch	2. P x Kt
3. Q to K 5 ch	3. K to B sq
4. Q to Kt 7 mate.	
	1. Kt to R 4
2. B to Q 7 ch	2. K x R
3. Kt to K B 6 ch	3. K to Q 3
4. Kt to Q B 6 mate.	

LETTER "L."—BY DR. C. C. MOORE.

WHITE.	BLACK.
1. Q to Kt 2	1. Kt x R ch
2. K x Q Kt	2. Any move
3. Mate follows.	